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TECHNICIAN CERTIFICATION for REFRIGERANTS

third edition

Howard Styles

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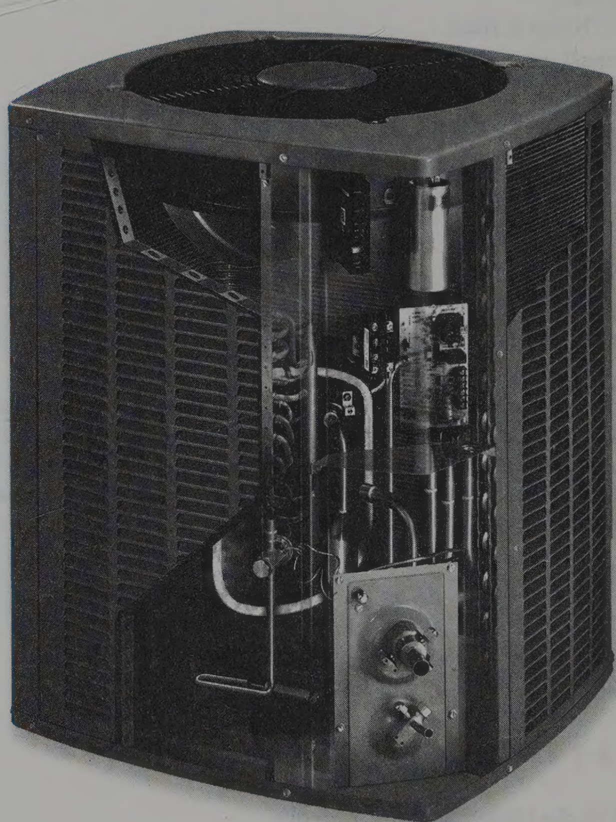

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Howard Styles

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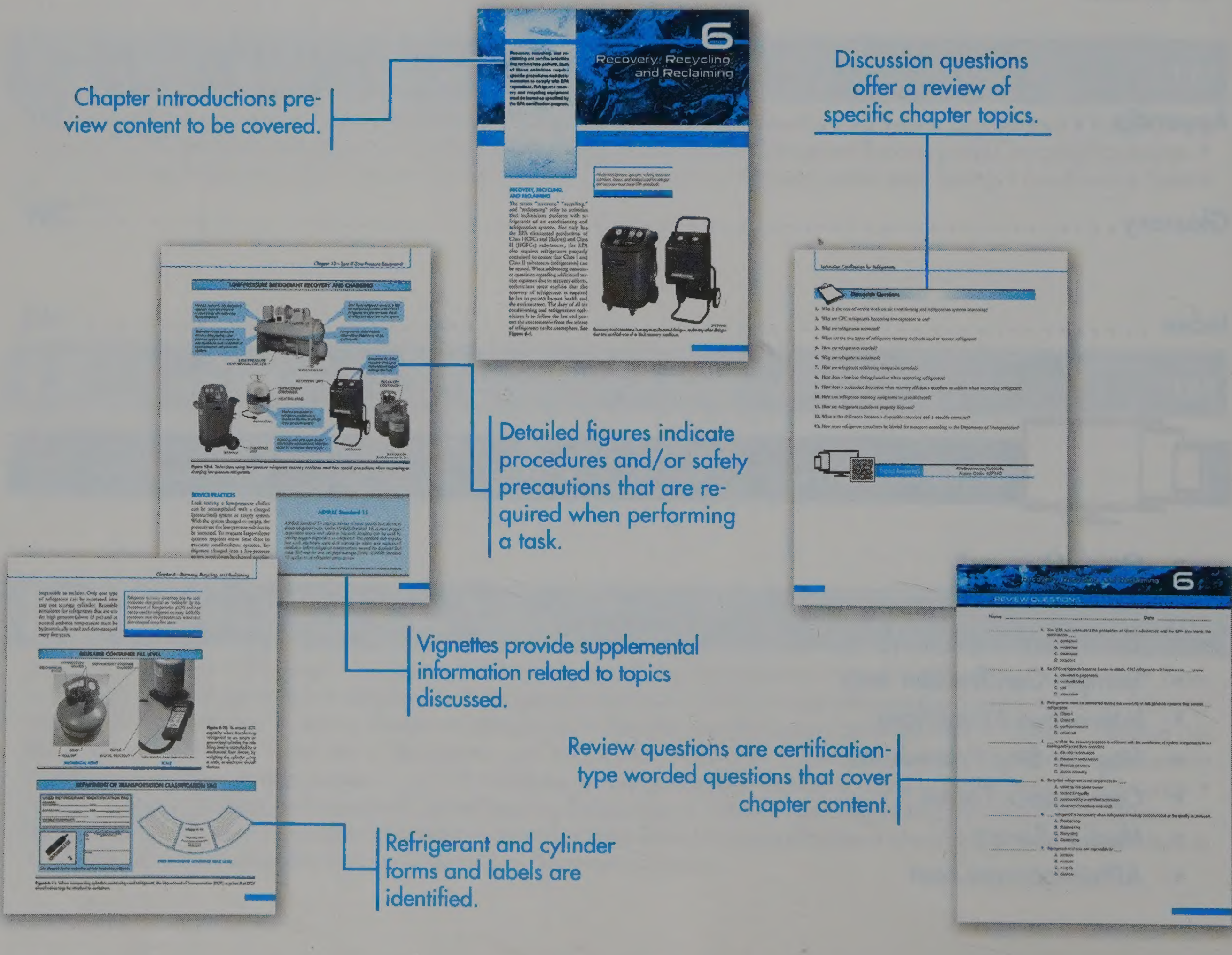
Introduction

Technician Certification for Refrigerants provides information on the recovery of refrigerants from air conditioning and refrigeration equipment. This third edition is specifically organized and formatted for easy use in preparing learners for the Type I, Type II, Type III, and Universal 608 refrigerant certification card tests and the Canadian ODP certification card test. Vignettes on technical topics, Environmental Protection Agency (EPA) standards, and common refrigerant recovery and charging procedures are located throughout the book to enhance understanding of the content covered.

This textbook includes information on the latest generation of refrigerants and the most up-to-date EPA and Environment Canada standards and regulations. Chapters 1–7, 9, 11, 13, 15, and 17 offer a comprehensive learning experience that includes numerous illustrations, discussion questions, and review questions (certification-test based). Chapters 8, 10, 12, 14, and 16 contain hundreds of updated sample 608 and Canadian certification test questions. Chapter 18 is a sample Universal Certification Test that has also been updated for the third edition.

The Appendix contains useful refrigerant recovery charts and compliance forms. The Glossary provides definitions for key terms found throughout the book.



Digital Resources

Digital learner resources enhance book content and can be accessed by the following:

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- Quick Response (QR) Code reader app to scan the QR Code on a mobile device

- **Quick Quizzes**® that provide 10 interactive questions for each chapter to reinforce fundamental concepts
- An **Illustrated Glossary** of terms, with links to selected illustrations
- **Flash Cards** for the review of common refrigerant and HVAC terms, definitions, and refrigeration system test tools
- **Sample Certification Tests** organized into five 25-question tests that provide practice with refrigeration certification tests in the United States and refrigerant-handling certification tests in Canada
- **Interactive Animations** that present refrigerant recovery procedures for Type I and Type II refrigeration systems per Section 608 of the Clean Air Act
- **Step-by-Step Procedures** that cover common refrigerant-handling tasks with drawings and concise text
- **Compliance Forms** that provide documentation for purchasing and working with refrigerants
- A **Media Library** that depicts principles and tasks using media clips and animations
- **ATPeResources.com,** which provides a comprehensive array of instructional resources

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The Publisher

1 Refrigeration Principles

Refrigeration is the process of moving heat from an area where it is undesirable to an area where it is not objectionable. Refrigeration is based on a law of physics that states that matter gains or loses heat when it changes state. The two main types of refrigeration processes are mechanical compression and absorption. The refrigerants that are affected by the Clean Air Act are refrigerants used in mechanical compression systems. At this time the Clean Air Act does not cover the refrigerants used in absorption-type refrigeration systems.

REFRIGERATION PRINCIPLES

Refrigeration is the process of moving heat from an area where it is undesirable to an area where the heat is not objectionable. According to the second law of thermodynamics, heat always flows from a material at a high temperature to a material at a low temperature.

A *refrigeration system* is a closed system that controls the pressure and temperature of a refrigerant to regulate the absorption and rejection of heat by the refrigerant. The low-pressure side of a refrigeration system decreases the temperature and pressure of the refrigerant, which allows the refrigerant to absorb heat from the medium (air or water) in the system. Air or water is cooled when heat is absorbed by the refrigerant. The air or water is then used for cooling building spaces. The high-pressure side of a refrigeration system increases the temperature and pressure on the refrigerant, which causes the refrigerant to reject heat to the air or water in the system. The heated air or water is used to remove heat to the atmosphere.

Refrigeration applications include commercial and industrial refrigeration and air conditioning. A commercial or industrial refrigeration system uses mechanical equipment to produce a refrigeration effect for applications other than human comfort. An air conditioning system also uses mechanical equipment to produce a refrigeration effect to maintain comfort within a building space.

According to Section 608 of the Clean Air Act, all refrigerant recovery and/or recycling equipment now manufactured must be certified and labeled by an EPA-approved equipment testing organization to meet EPA standards. This covers all air conditioning and refrigeration equipment containing CFC and HCFC refrigerants.

> Technical Fact

MECHANICAL COMPRESSION REFRIGERATION

Mechanical compression refrigeration is a refrigeration process that produces a refrigeration effect with mechanical equipment. A mechanical compression refrigeration system consists of a compressor, condenser, expansion device, evaporator, refrigerant lines, and accessories that contain refrigerant. **See Figure 1-1.**

A *compressor* is a mechanical device that compresses refrigerant or other fluid. A compressor increases the temperature of, and pressure on, refrigerant vapor and produces the high pressure in the high-pressure side of the system. A refrigerant is a fluid that is used for transferring heat in a refrigeration system. Most refrigerants have a low boiling (vaporization) point. Low-boiling-point refrigerants boil and vaporize at room temperature.

A *condenser* is a heat exchanger that removes heat from high-pressure refrigerant vapor. High-pressure refrigerant vapor flows through a condenser and the condensing medium passes across the outside of the condenser. Heat flows from the hot refrigerant vapor to the cold condensing medium. A *condensing medium* is a fluid (air or water) that has a lower temperature than the refrigerant, which causes heat to flow to the medium. Condensing mediums remove heat from refrigerants because the mediums have lower temperatures than the refrigerants. Air and water are condensing mediums used in refrigeration systems. As refrigerant vapor gives up heat to the condensing medium moving across a condenser, the refrigerant vapor condenses to a liquid.

An *expansion valve* is a valve or mechanical device that reduces the pressure of liquid refrigerant by allowing the refrigerant to expand. As the pressure of the liquid refrigerant decreases, some of the liquid refrigerant vaporizes because of its lowered boiling point. The vaporizing refrigerant absorbs heat from the liquid refrigerant, which cools the liquid refrigerant. The cooled refrigerant then flows as a liquid or liquid-vapor mixture to the evaporator.

MECHANICAL COMPRESSION REFRIGERATION

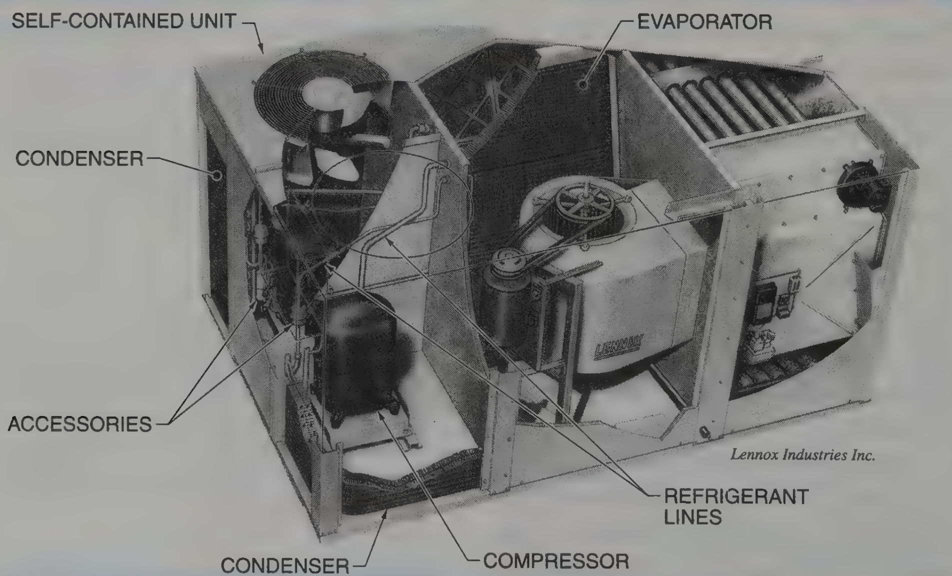


Figure 1-1. A mechanical compression refrigeration system uses mechanical equipment to produce a refrigeration effect.

An *evaporator* is a heat exchanger where heat is absorbed into the low-pressure liquid refrigerant. Low-pressure liquid refrigerant flows through the evaporator as an evaporating medium passes across the outside of the evaporator. Heat flows from the warm evaporating medium to the lower temperature refrigerant. An *evaporating medium* is a fluid (air or water) that is cooled when heat is transferred from the medium to the cold refrigerant. An evaporating medium adds heat to refrigerant because the medium has a higher temperature than the refrigerant. As the liquid refrigerant absorbs heat from the evaporating medium, the refrigerant boils and vaporizes.

Refrigerant piping carries refrigerant and connects the components of a mechanical compression refrigeration system. Accessories monitor and adjust the system to ensure proper operation.

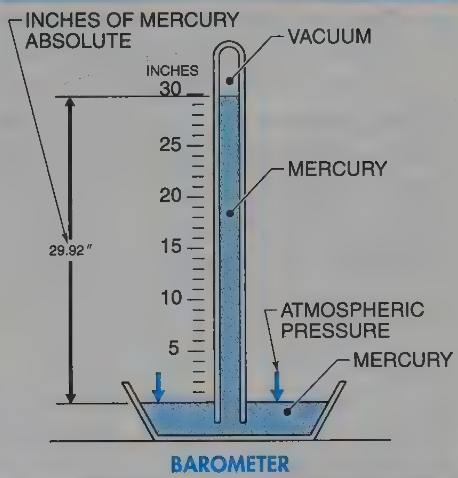
Pressure-Temperature Relationships

Pressure is the force per unit of area that is exerted by an object or a fluid. Pressure is expressed in pounds per square inch (psi). *Atmospheric pressure* is the force exerted by the weight of the atmosphere on the surface of the Earth. Atmospheric pressure is measured at sea level and is normally expressed in pounds per square inch absolute (14.696 psia). **See Figure 1-2.** Atmospheric pressure is measured precisely with a mercury barometer.

A *mercury barometer* is an instrument used to measure atmospheric pressure and is calibrated in inches of mercury absolute (in. Hg abs). A mercury barometer consists of a glass tube that is closed on one end and filled completely with mercury. The tube is inverted in a dish of mercury. A vacuum is created at the top of the tube as the mercury tries to run out of the tube.

Vacuum is any pressure lower than atmospheric pressure. Vacuum is expressed in inches of mercury (in. Hg) or microns. The pressure of the atmosphere on the mercury in the open dish prevents the mercury in the tube from running out of the tube. The height of the mercury in the tube corresponds to the pressure of the atmosphere on the mercury in the open dish. Minute pressure changes can be expressed in microns.

PRESSURE AND VACUUM EQUIVALENTS



	PSI or PSIG	PSIA	Hg ABS*	Hg* Vacuum	Micron Vacuum
2 Atmosphere	14.696	29.392	59.84	——	——
1 Atmosphere	0	14.696	29.92	0	760,000
	——	12.24	24.92	5	632,968
	——	4.912	10	19.92	254,000
	——	2.456	5.0	24.92	127,000
	——	1.0	2.036	27.884	51,715
	——	0.452	0.92	29.00	23,368
	——	0.099	0.2	29.72	5000
	——	0.019	0.1	29.82	1000
	——	0.010	0.019	29.901	500
	——	0.002	0.003	29.917	100
	——	0.001	0.001	29.919	50
Perfect vacuum	——	0	0	29.92	0

* in in.

Figure 1-2. A mercury barometer is an instrument used to measure atmospheric pressure and is calibrated in inches of mercury absolute.

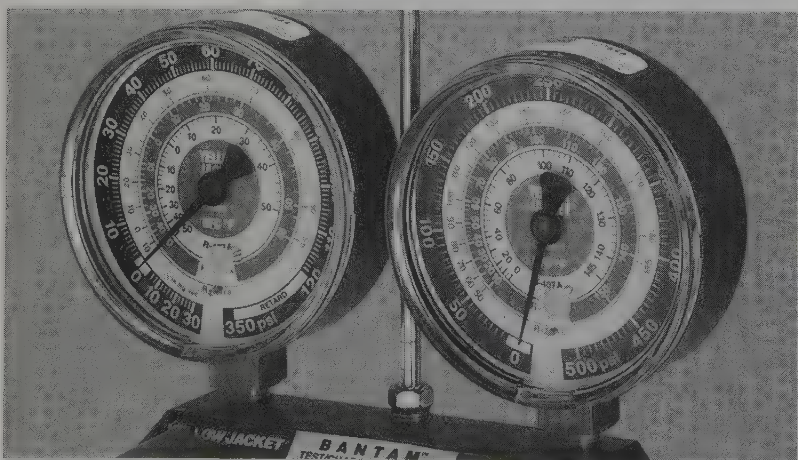
Gauge pressure is pressure above atmospheric pressure that is used to express pressures inside a closed system. Gauge pressure is expressed in pounds per square inch gauge (psig or psi). *Absolute pressure* is any pressure above a perfect vacuum (0 psia). Absolute pressure is the sum of gauge pressure plus atmospheric pressure. Absolute pressure is expressed in pounds per square inch absolute (psia).

Pressure outside a closed system, such as normal air pressure, is expressed in pounds per square inch absolute. The difference between gauge pressure and absolute pressure is the pressure of the atmosphere at sea level with standard conditions (14.7 psia). A pressure gauge reads 0 psi at normal atmospheric pressure. To find absolute pressure when gauge pressure is known, add the atmospheric pressure of 14.7 to the gauge pressure. Absolute pressure is found by applying the formula:

$psia = psi + 14.7$

where

$psia$ = pounds per square inch absolute
psi = pounds per square inch gauge
14.7 = constant



Yellow Jacket Div., Ritchie Engineering Co., Inc.

A low-pressure gauge is calibrated in pounds per square inch (psi) from 0 psi to 120 psi, and in inches of mercury (in. Hg) vacuum from 0 in. Hg to 30 in. Hg and is color coded blue. A high-pressure gauge is calibrated in psi from 0 psi to 500 psi and is color coded red.

Refrigerant pressure gauges often have the corresponding saturation temperatures printed on the dial of the gauge for one or more refrigerants. Refrigerant-specific gauges will show the corresponding temperature of a refrigerant at a given pressure. Bourdon tube pressure gauges are often liquid-filled for surge protection.

▶ Technical Fact

Example: Finding Absolute Pressure

A gauge reads 68 psi on the low-pressure side of an operating refrigeration system. Find the absolute pressure.

$psia = psi + 14.7$
$psia = 68 + 14.7$
$psia =$ **82.7 psia**

Boiling point is the temperature at which a liquid vaporizes. The boiling point of a liquid is directly related to the pressure on the liquid. **See Figure 1-3.** If the pressure on a liquid increases, the boiling point will be higher. If the pressure on a liquid decreases, the boiling point of the liquid will be lower. For example, at 14.7 psia, the boiling point of water is 212°F. If the pressure on the water is increased, the boiling point of the water will be higher. At 29.8 psia, the boiling point of water is 250°F. If the pressure on the water is decreased, the boiling point of water will be lower. At 11.0 in. Hg or 9.3 psia (vacuum), the boiling point of water is 190°F.

Condensing point is the temperature at which a vapor condenses to a liquid. If the pressure on a vapor decreases, the temperature at which the vapor condenses into a liquid decreases. If the pressure on a vapor increases, the temperature at which the vapor condenses into a liquid increases. All substances follow this pressure-temperature relationship.

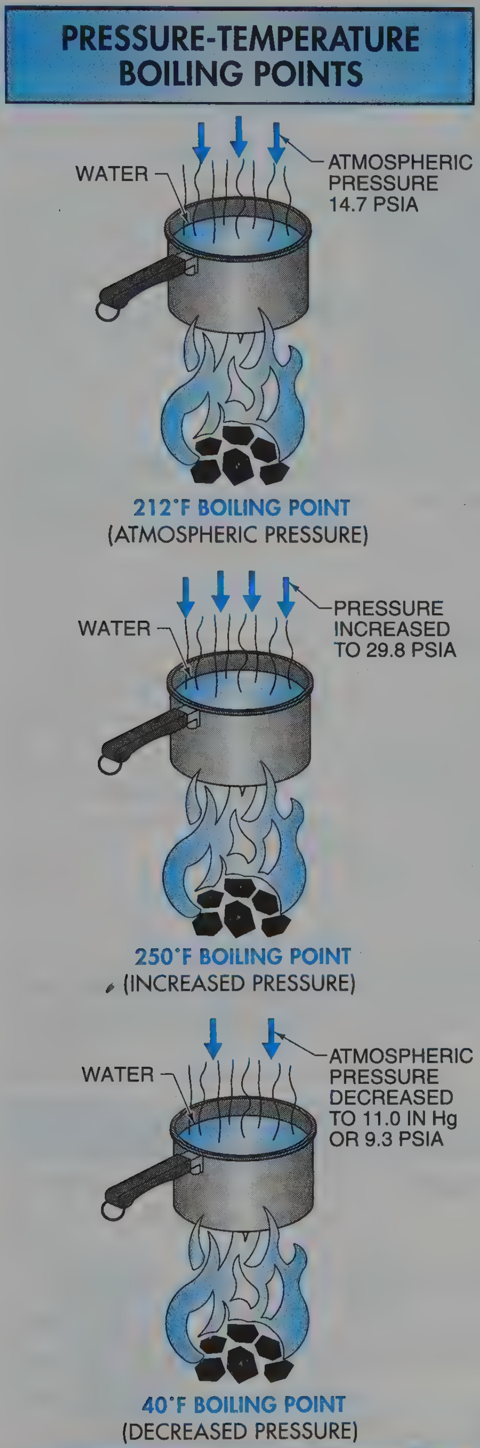


Figure 1-3. The boiling point of a liquid is directly related to the pressure on the liquid.

Heat Transfer

In a mechanical compression refrigeration system, heat transfer occurs in the condenser and the evaporator. In the condenser, heat is transferred from the refrigerant that flows through the condenser to the condensing medium that passes across the outside of the condenser. The refrigerant condenses as heat is rejected to the condensing medium. The heat transfer process of the condenser heats the condensing medium. **See Figure 1-4.**

In the evaporator, heat is transferred from the evaporating medium that passes across the outside of the evaporator to the refrigerant that flows through the evaporator. The refrigerant vaporizes as heat is absorbed from the evaporating medium. The evaporating medium (building air or water) is cooled by the evaporator heat transfer process.

Pressure Control

Mechanical compression refrigeration systems have a high-pressure side and a low-pressure side. Pressure is controlled in the low-pressure side by reduced refrigerant flow controlled by the expansion device, and by the suction of the compressor. **See Figure 1-5.**

An expansion valve meters the flow of refrigerant in a refrigeration system. Expansion valves are located just before the evaporator in the liquid line. The *liquid line* is the refrigerant pipe or tubing that connects the condenser outlet and the expansion device.

As liquid refrigerant flows through an expansion valve, the pressure of the refrigerant is decreased. The decreased pressure causes some of the refrigerant to vaporize. The vaporized refrigerant draws heat away from the rest of the liquid refrigerant, decreasing the liquid refrigerant temperature. **See Figure 1-6.** The liquid-vapor mixture flows from the expansion valve directly into the evaporator. The pressure of the refrigerant remains basically the same through the low-pressure side of the system except for minor pressure drops caused by the evaporator, lines, and fittings.

Discussions on the phase-out of R-134a have been started by the White House. Refrigerant HFO-123YF is the leading alternative to replace R-134a at this time.

▶ Technical Fact

HEAT TRANSFER

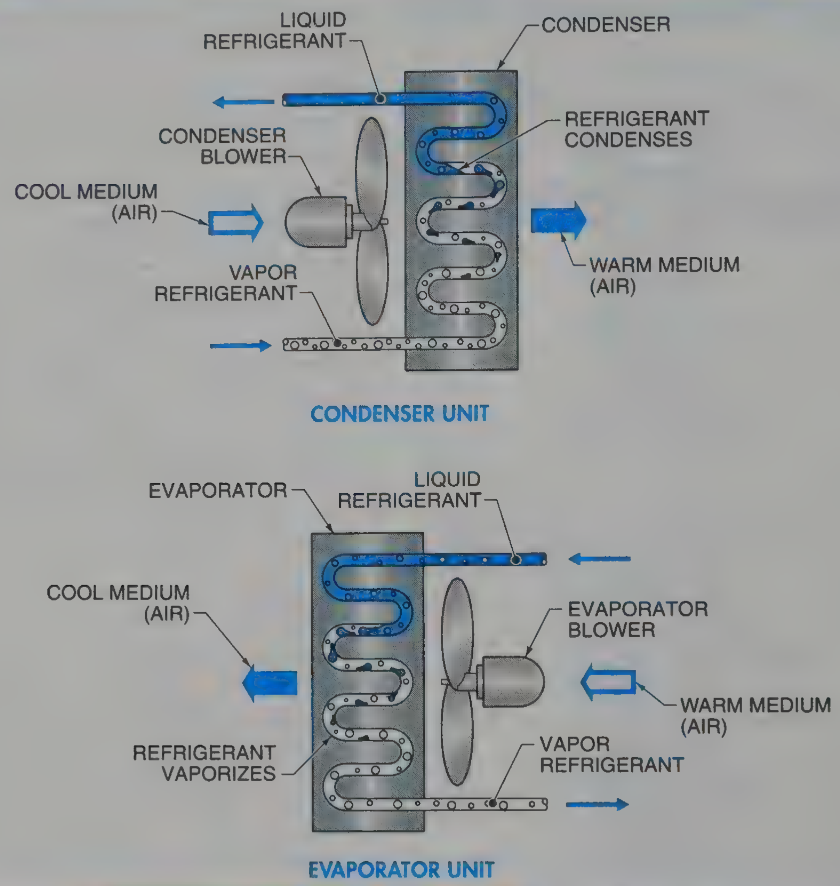


Figure 1-4. In a mechanical compression refrigeration system, heat transfer occurs in the condenser and evaporator.

REFRIGERATION SYSTEMS

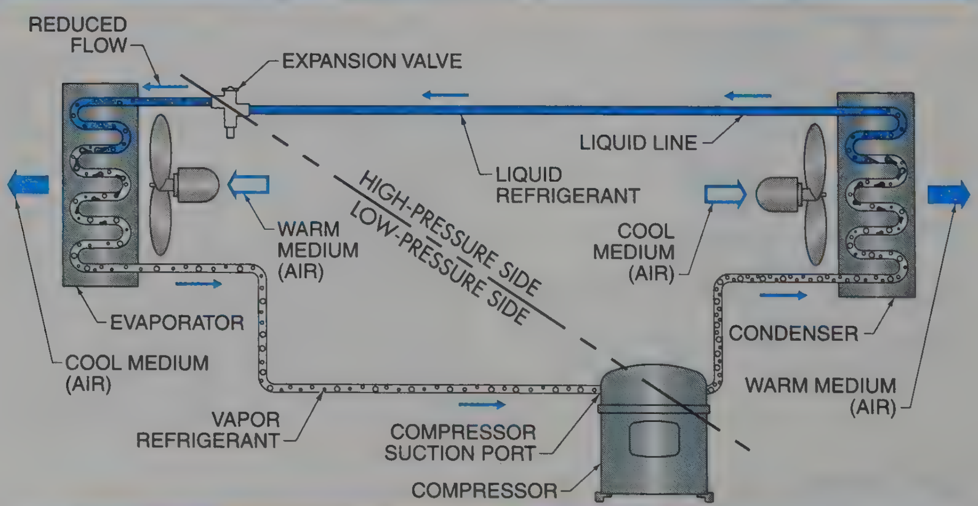


Figure 1-5. Pressure is controlled in a refrigeration system by the expansion valve controlling the refrigerant flow and by the suction of the compressor.

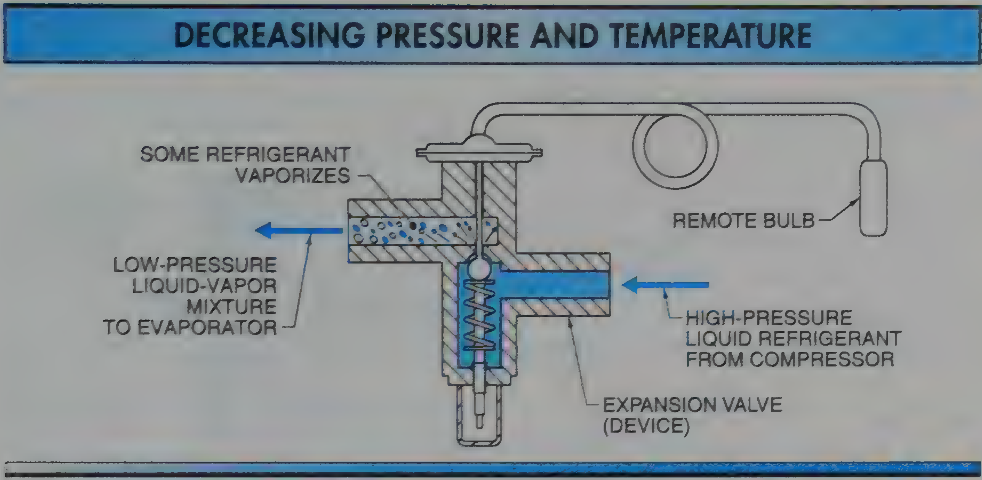


Figure 1-6. As liquid refrigerant flows through an expansion valve, the pressure of the refrigerant is decreased, causing some of the refrigerant to vaporize.

Compressor suction pressure is the lower pressure created at the suction port of a compressor as refrigerant is drawn into the compressor. The compressor suction maintains the low pressure in the low-pressure side of the system. Because refrigerant vapor is drawn out of the evaporator to the inlet of the compressor (suction port) as fast as the refrigerant is introduced through the expansion valve, the pressure on the low-pressure side of the system remains basically constant.

Compressor discharge flow maintains the high pressure in the high-pressure side of a refrigeration system. Refrigerant leaves the system evaporator as a vapor and flows to the compressor. *Compressor discharge pressure* is the pressure created by the resistance to flow of the refrigerant when discharged from the compressor.

The refrigerant vapor is compressed in the compressor and is pushed from the compressor at a higher pressure. **See Figure 1-7.** Because the refrigerant absorbs heat from the compression process and possibly the compressor motor windings, the refrigerant that leaves the compressor is hotter than the refrigerant in the rest of the refrigeration system. The hot refrigerant vapor discharged from the compressor flows to the condenser. The pressure in the high-pressure side of the system is constant except for minor pressure drops created by the friction of fittings and refrigerant lines.

Due to the low pressure in the evaporator and compressor suction port, the temperature of the refrigerant is decreased to a temperature lower than the temperature of the evaporating medium. The temperature difference causes heat to flow from the evaporating medium to the refrigerant. Because of the high pressure in the compressor discharge port and condenser, the temperature of the refrigerant is increased to a temperature higher than the temperature of the condensing medium. The temperature difference causes heat to flow from the refrigerant to the condensing medium.

The capacity of a refrigeration unit is stated in tons. The refrigeration ton is the cooling effect of 1 ton (2000 pounds) of ice at 32°F melting in 24 hours. The number of Btu required to melt 1 ton of ice is 144 x 2000 = 288,000 Btu in 24 hr or 12,000 Btu/hr.

► Technical Fact

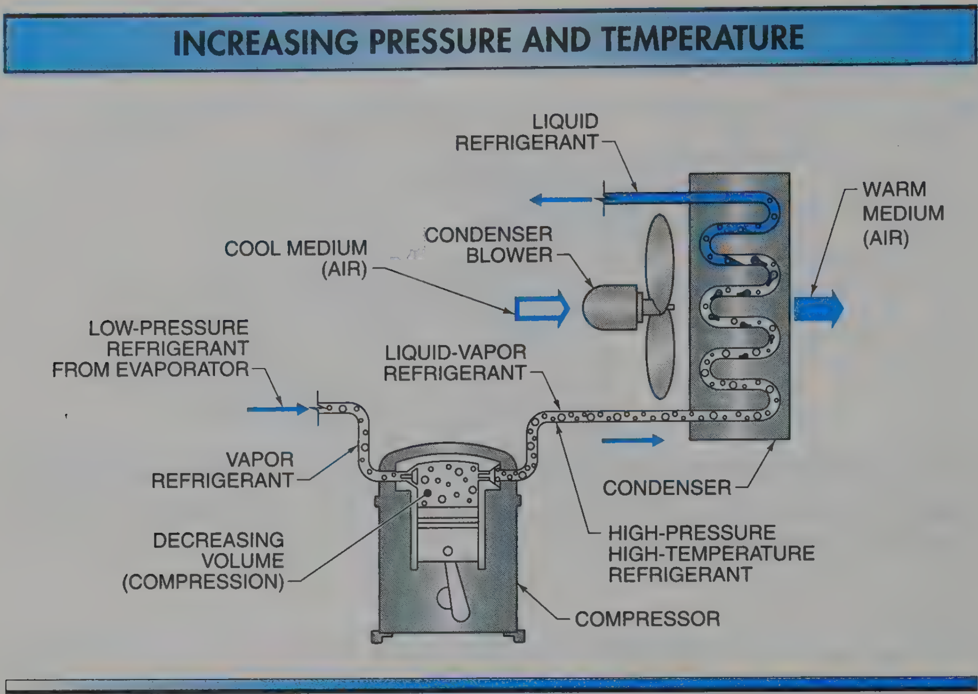


Figure 1-7. Refrigerant vapor is compressed in the compressor and pushed from the compressor at a higher pressure.

An example of a mechanical compression refrigeration system is a household freezer. **See Figure 1-8.** Inside a freezer, refrigerant circulates through the evaporator and absorbs heat from the food. The heat vaporizes the liquid refrigerant. The refrigerant vapor is drawn out of the evaporator by the suction of the compressor. The compressor compresses the refrigerant, which raises the pressure and temperature of the refrigerant. The refrigerant is pushed into the condenser, which is located on the rear of the freezer. The heat absorbed from the food inside the freezer is released to the air outside the freezer by the condenser.

Operation

The operation of a refrigeration system is as follows:

1. R-410a refrigerant enters the evaporator of a refrigeration system with a pressure of 118.4 psi, a temperature of 40°F, and a heat content of approximately 50.2 Btu/lb. **See Figure 1-9.** The boiling point of R-410a at 133 psia is 40°F. The temperature of the refrigerant remains at about 40°F as it moves through the evaporator. Air that is about 80°F passes across the outside of the evaporator and is warmer than the refrigerant in the evaporator. The refrigerant absorbs the heat and vaporizes.

   The evaporator is large enough to allow the refrigerant to completely vaporize before it leaves the evaporator. The refrigerant absorbs superheat in the last few rows of coils in the evaporator. *Superheat* is the heat added to a refrigerant after the refrigerant has changed state into a vapor. The refrigerant leaves the evaporator at a temperature higher than the saturated temperature for the pressure. The refrigerant has more heat than if the refrigerant is saturated because of the superheat absorbed from the evaporator.

FREEZER

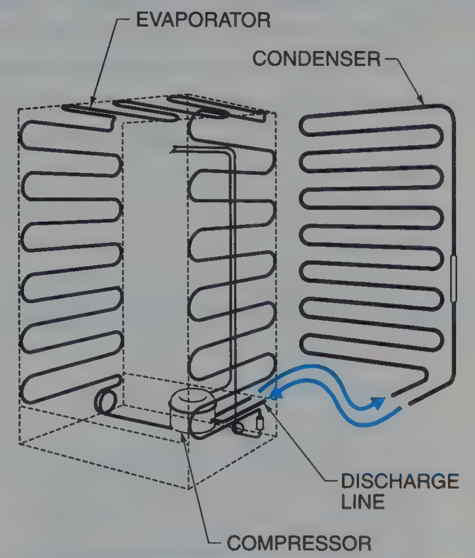


Figure 1-8. A freezer removes heat from food through the evaporator and releases the heat to the air outside the freezer through the condenser.

2. The refrigerant vapor leaves the evaporator with a pressure of 118.4 psi, a temperature of 50.0°F, and a heat content of approximately 122.2 Btu/lb. The refrigerant absorbs heat from the evaporating medium, which raises the temperature and heat content of the refrigerant. The refrigerant leaves the evaporator through the suction line. The *suction line* is the pipe or tubing that connects the evaporator and the suction port of the compressor.

In the compressor the pressure of the refrigerant rises to 341.9 psi and to 182°F. The temperature of the refrigerant rises from the heat of compression and, in certain compressors, from cooling the compressor motor windings with the refrigerant that is flowing through the compressor.

REFRIGERATION SYSTEM OPERATION

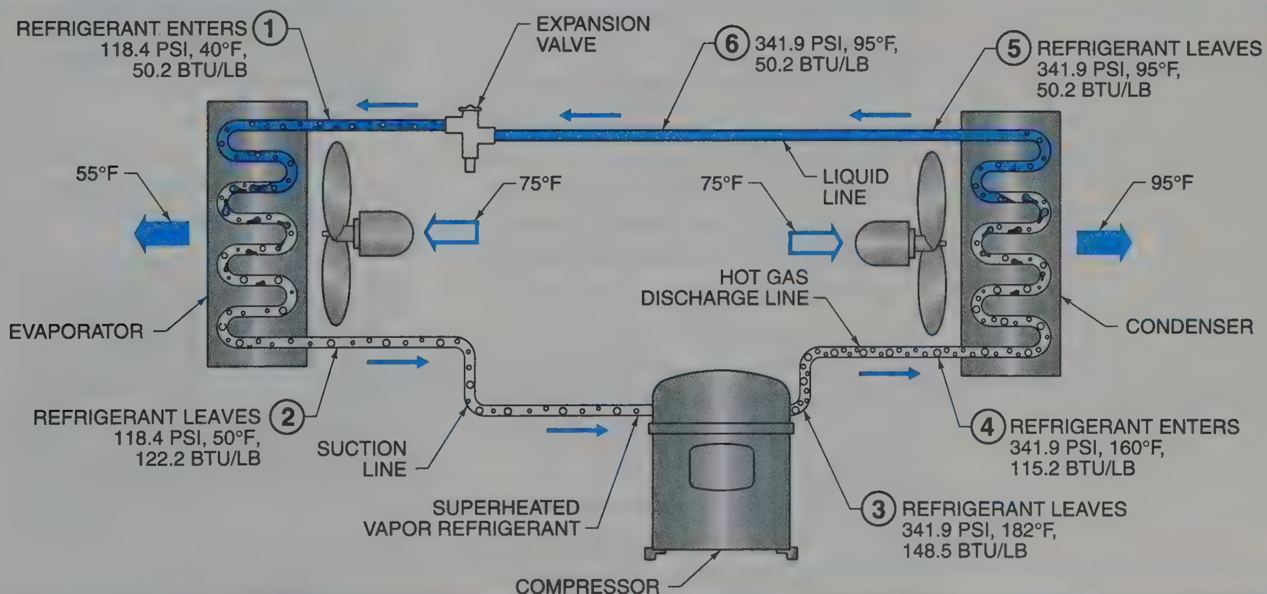


Figure 1-9. The temperature and pressure of a refrigerant change as the refrigerant passes through various components of a mechanical compression refrigeration system.

3. The refrigerant vapor leaves the compressor with a pressure of 341.9 psi, a temperature of 182°F, and a heat content of 148.5 Btu/lb of refrigerant. The saturated temperature of the refrigerant at 341.9 psi is 140°F, but the actual temperature of refrigerant leaving the compressor is 182°F due to superheating. The refrigerant leaves the compressor through the hot gas discharge line and moves to the condenser.

   The *hot gas discharge line* is the pipe or tubing that connects the compressor to the condenser. The hot gas discharge line contains the hot gas (refrigerant vapor) that will be cooled in the condenser. While the refrigerant moves through the hot gas discharge line, the refrigerant loses some of the superheat absorbed in the compressor. By the time the refrigerant reaches the condenser, the refrigerant is closer to saturated temperature.
4. The refrigerant enters the condenser from the hot gas discharge line with a pressure of 341.9 psi, a temperature of 160°F, and a heat content of 115.2 Btu/lb. Heat flows from the refrigerant to the condensing medium because the temperature of the condensing medium is lower than the temperature of the refrigerant in the condenser. The amount of heat rejected by the refrigerant in the condenser is the same as the amount of heat absorbed by the refrigerant in the evaporator and compressor. As the refrigerant rejects heat in the condenser, the refrigerant changes state from a vapor back to a liquid.
5. The R-410a refrigerant leaves the condenser at the same pressure, 341.9 psi, but the refrigerant is now a liquid. Most condensers are sized with extra capacity so that the refrigerant completely condenses to a liquid, but still allow extra cooling (subcooling) to take place while the refrigerant is in a liquid state. *Subcooling* is the cooling of a refrigerant to a temperature that is lower than the saturated temperature of the refrigerant for a particular pressure. With the subcooling of the condenser, the refrigerant leaves the condenser with a temperature of 95°F and a heat content of approximately 50.2 Btu/lb.

   The refrigerant leaves the condenser through the liquid line and moves either directly to an expansion device or to a receiver tank. When the refrigerant enters the expansion valve, the refrigerant will have almost the same pressure and temperature that it had when it left the condenser.
6. The refrigerant flows through the expansion valve. The restriction in the expansion device causes a pressure decrease. The pressure decrease is the difference between the high-pressure side and low-pressure side of the system. The decreased pressure allows 15% of the refrigerant to vaporize, which causes a temperature decrease from 95°F to 40°F. The boiling point of the R-410a refrigerant on the low-pressure side is 40°F.

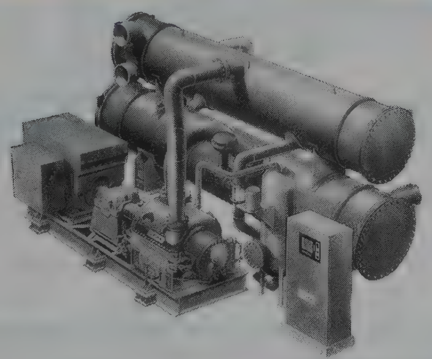
   After flowing through the expansion valve, the refrigerant enters the evaporator at 118.4 psi as a liquid-vapor mixture and the cycle begins again.

CHILLERS

A *chiller* is a piece of refrigeration equipment that removes heat from water that circulates through a building for cooling purposes. The chilled water is circulated to the cooling coils of a building at about 45°F. The chilled water increases in temperature about 10°F as the

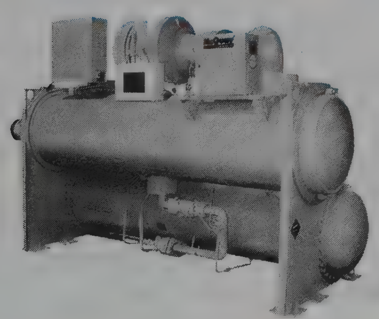
water flows through the cooling coils. The water is returned to the chiller at a temperature of about 55°F to be cooled again. The three basic types of chillers are high-pressure chillers, low-pressure chillers, and absorption chiller. **See Figure 1-10.**

CHILLER TYPES



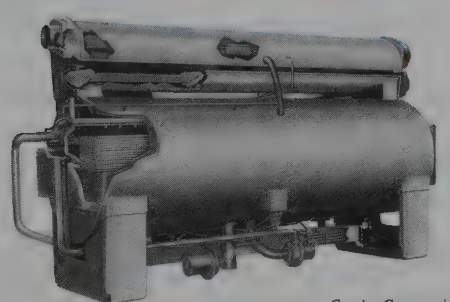
York International Corp.

HIGH-PRESSURE DUAL-COMPRESSOR CENTRIFUGAL CHILLER



McQuay International

LOW-PRESSURE SINGLE-COMPRESSOR CENTRIFUGAL CHILLER



Carrier Corporation

ABSORPTION CHILLER

Figure 1-10. The three types of chillers used in commercial buildings are high-pressure chillers, low-pressure chillers, and absorption chiller.

High- and Low-Pressure Chillers

A high-pressure chiller operates at a pressure above 14.7 psia and low-pressure chillers operate at 14.7 psia (vacuum) on the low side. High-pressure chillers and low-pressure chillers utilize a compressor in the compression cycle to create the pressure differences inside the chiller to vaporize and condense refrigerant. A compression chiller has components similar to the basic refrigeration systems, such as a compressor, a condenser, metering devices, and evaporator. **See Figure 1-11.** Low-pressure chillers also have a purge unit to remove "noncondensables" from the system. Chiller components are typically large. The large components allow a chiller to handle large volumes of refrigerant.

Compressors. The compressors typically used in high-pressure chillers are reciprocating, scroll, or screw. Low-pressure chillers use centrifugal compressors. A compressor is the pumping component that creates the refrigerant flow through the evaporator and condenser of a mechanical compression refrigeration system. **See Figure 1-12.** The pressure corresponds to a designed evaporating temperature of 38°F and a condensing temperature of 105°F. For R-134a, the evaporator pressure would be about 33 psi and the condenser pressure would be about 135 psi, which would make the chiller a high-pressure chiller. A low-pressure chiller might use R-123 refrigerant. R-123 has an evaporator pressure of about 17.5 in Hg vacuum and a condenser pressure of about 8.1 psi.

For years, low-pressure centrifugal chillers have used R-11 refrigerant. Today R-123 replaces R-11. In the past, high-pressure chillers used R-12 refrigerant. Today, R-134a replaces R-12. Positive displacement chillers used R-22 refrigerant for many years. Today R-407C and R-410a replace R-22 in most applications.

Technical Fact

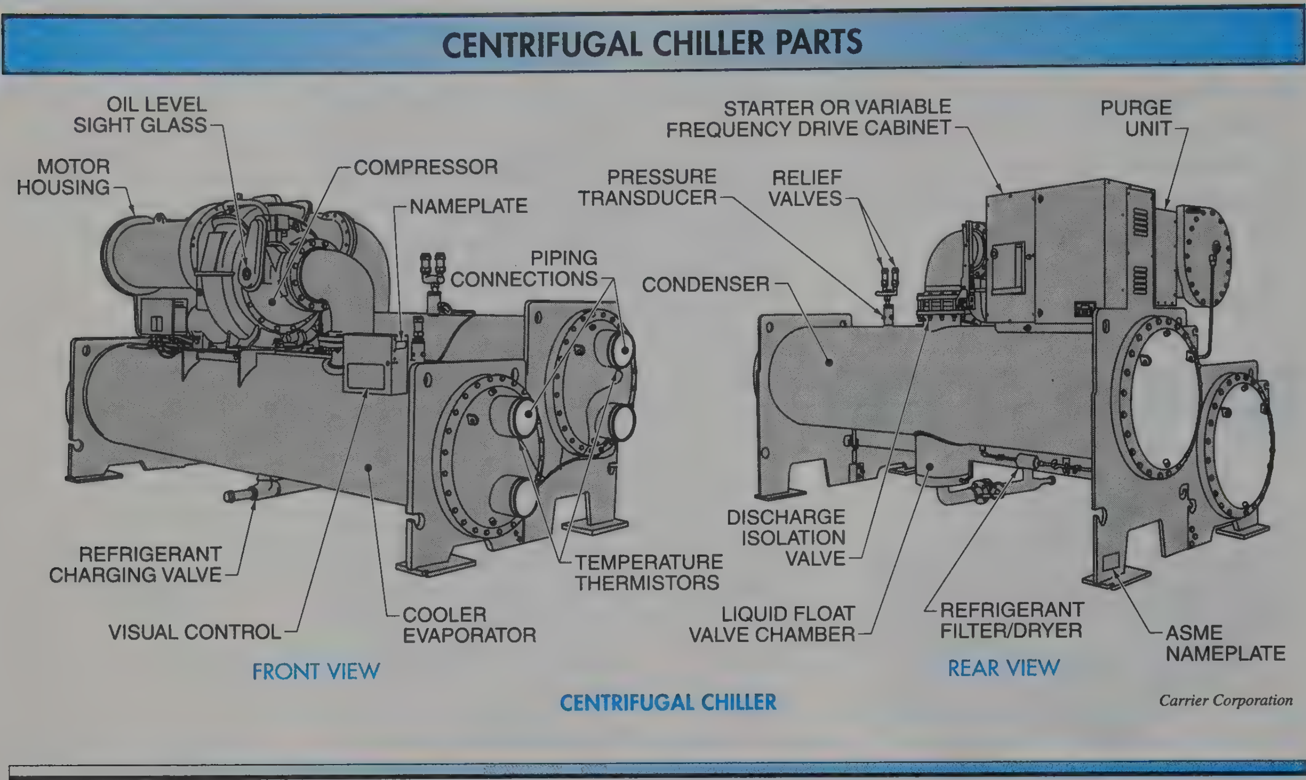


Figure 1-11. High-pressure and low-pressure chillers use components similar to components found in all refrigeration systems, such as a compressor, a condenser, an evaporator, and metering devices.

Reciprocating compressors used for chillers are similar to those used in other air conditioning and refrigeration systems. Most reciprocating compressors have multiple cylinders to allow higher system volumes. Higher system volumes are accomplished by having four or six cylinders on one, two, or more compressors. For example, a chiller may have four stages of compression utilizing two reciprocating compressors. Each compressor will have two cylinders, with one of the cylinders on each compressor having a cylinder unloader. **See Figure 1-13.** A *cylinder unloader* is a device that holds the suction valve closed or holds the suction valve open on a cylinder.

A cylinder that has an operating unloader will not compress refrigerant. On a call for cooling, the first reciprocating compressor will turn ON with one cylinder unloaded. At this point the chiller is operating at 25% of designed capacity. With an increase in load, the second cylinder will load and compressor 1 is operating at full capacity with the chiller operating at 50% of its designed capacity.

As the cooling load continues to increase, the second reciprocating compressor will turn ON with one cylinder unloaded. The chiller is now operating at 75% of its designed capacity. If the load continues to increase, the second compressor loads cylinder 2. Now both of the reciprocating compressors are operating at full capacity and the chiller is operating at 100% of design capacity.

Scroll compressors are also positive-displacement compressors. When used in chillers, they are normally in the 10- to 15-ton size range and operate the same as the small units. A ton of cooling is the amount of heat required to melt a ton of ice in a 24-hour period. The capacity control of a chiller is obtained by cycling the compressors ON

and OFF as required. For example, a 25-ton chiller can have two scroll compressors of different sizes or the same size. One compressor can be a 10-ton unit and the other compressor a 15-ton unit. The chiller has variable capacity of 10, 15, or 25 tons of cooling. Two advantages scroll compressors have over reciprocating compressors are that scroll compressors run quieter and are able to handle small amounts of liquid refrigerant.

Rotary screw compressors used in chillers are large-capacity, positive-displacement compressors that have few moving parts. Rotary screw compressors are reliable, trouble-free units that can handle slugs of liquid refrigerant. Capacity control is obtained by a slide valve that modulates open and closed to control the amount of refrigerant admitted to the compressor as determined by the cooling load.

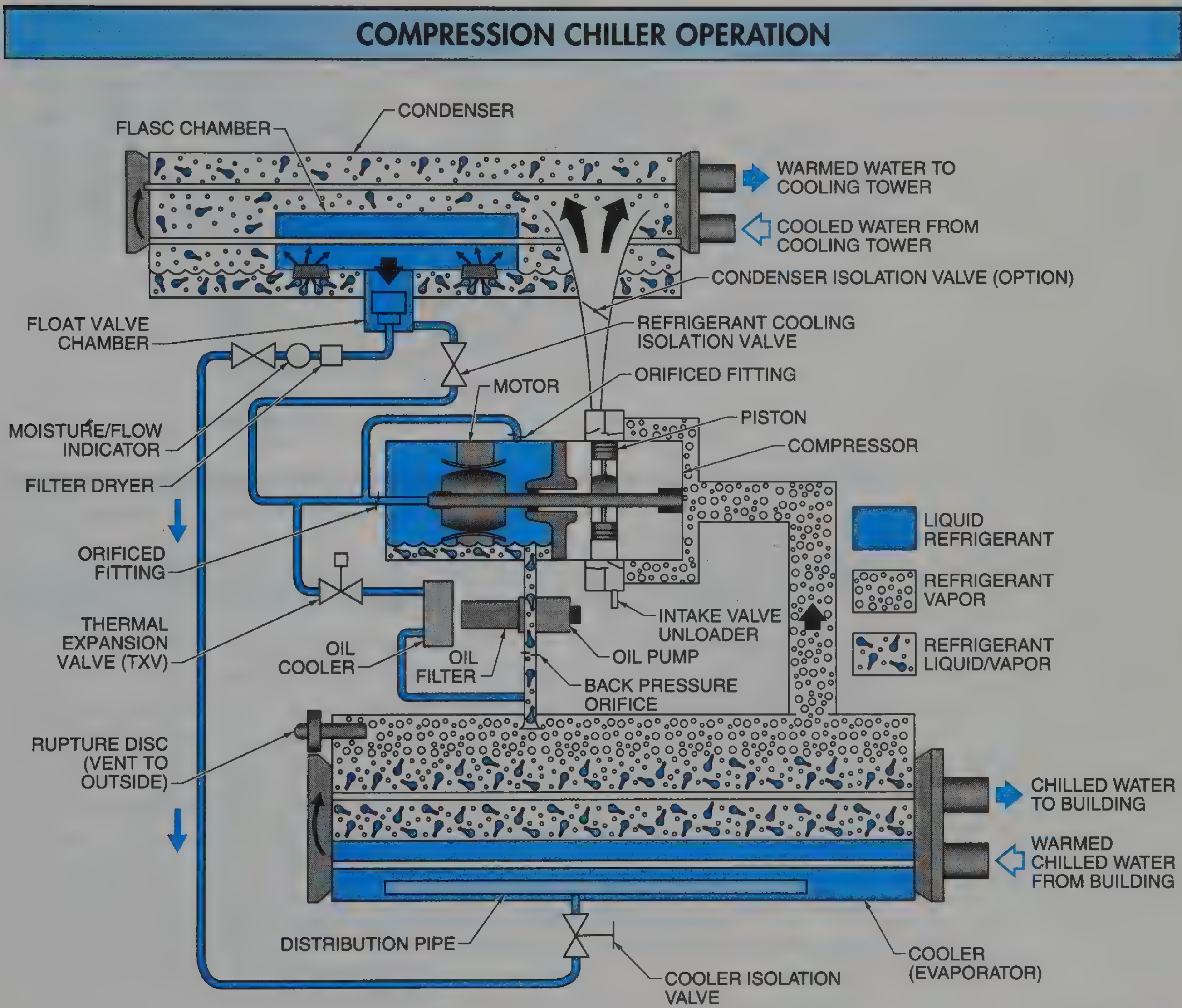


Figure 1-12. A compressor is the pumping component that causes refrigerant to flow through the evaporator and condenser of a mechanical compression refrigeration system.

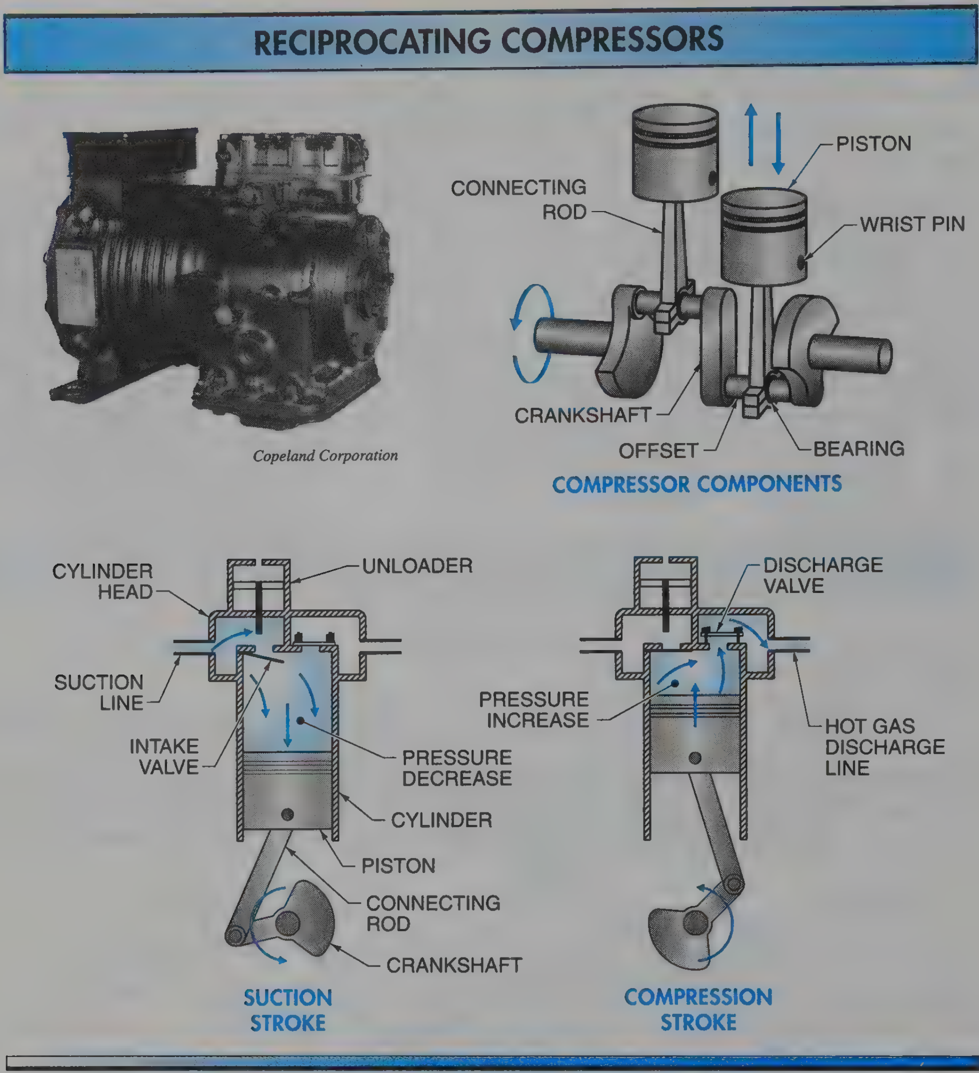


Figure 1-13. High-pressure systems use reciprocating compressors with two or more stages to achieve high operating pressures.

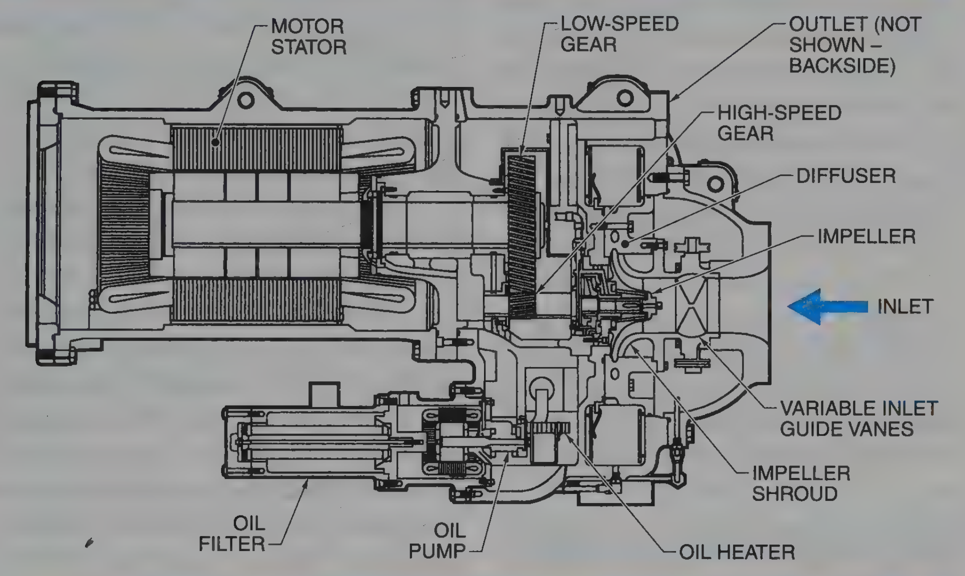
Centrifugal compressors used on chillers utilize the centrifugal force applied to the refrigerant by a fast-spinning impeller. **See Figure 1-14.** The motor of the compressor is directly connected to a transmission that can have gear ratios of up to 9 to 1. When the speed of the motor is 3450 rpm, the impeller on some high-pressure, single-stage compressors may approach 30,000 rpm.

Centrifugal compressors do not produce a great deal of force but they can handle large volumes of refrigerant. If a greater pressure differential is required than one impeller can produce, multiple impellers (stages) are operated in series. The discharge of one impeller enters the inlet (eye) of the next impeller. Centrifugal chillers are available in units with capacity ratings of 100 tons and up. Capacity control is obtained on a centrifugal chiller by inlet vanes or by variable frequency drivesvariable frequency drives (VFD) controlling the electric motor.

Condensers. The condenser is a component of a chiller that transfers heat from the refrigerant to a cooling

medium. The cooling medium is typically water but can be air. On a water-cooled chiller, the condenser is typically a two-pass, tube-and-shell heat exchanger. **See Figure 1-15.** The water is in the tubes and the refrigerant surrounds the tubes. The refrigerant in the condenser transfers heat to the water, raising the water temperature to about 95°F. The heated water leaves the condenser and is circulated to a cooling tower where the heat of the water is dissipated to the surrounding air. The water is circulated back to the condenser, at a lower design temperature of 85°F, to start the process again.

CENTRIFUGAL COMPRESSORS



Carrier Corporation

Figure 1-14. Centrifugal compressors do not produce a great deal of force, but can handle large volumes of refrigerant.

CONDENSER TUBE-AND-SHELL HEAT EXCHANGERS

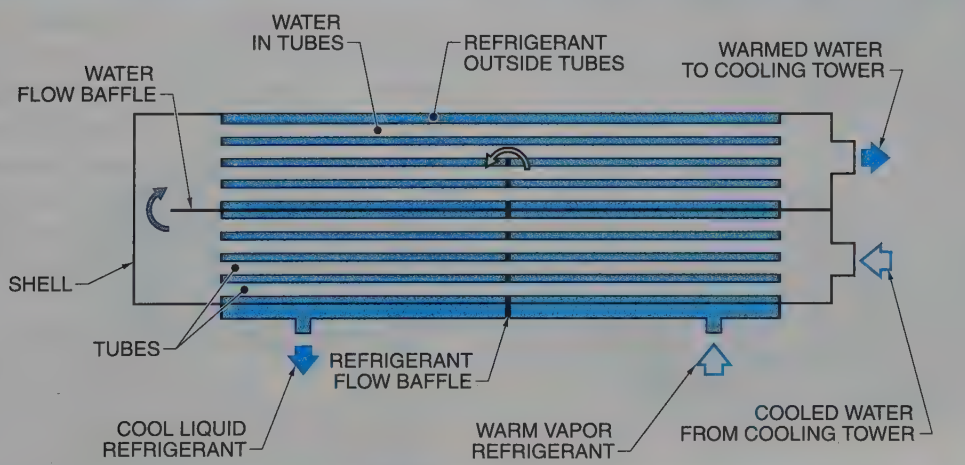
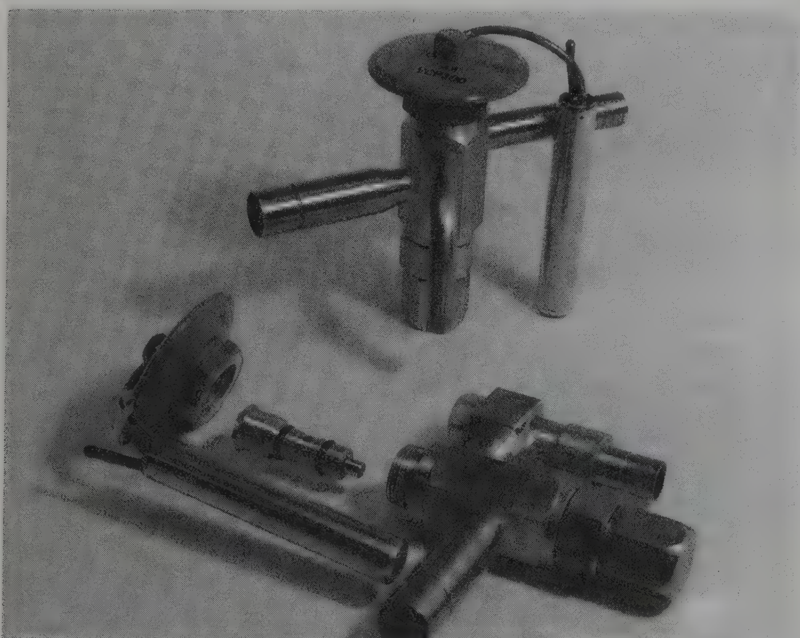


Figure 1-15. Water-cooled chillers typically have a condenser that is a two-pass, tube-and-shell heat exchanger.

Metering Devices. A *metering device* is a valve or orifice in a refrigeration system that controls the flow of refrigerant into the evaporator to maintain the correct evaporating medium temperature. The four types of metering devices used on high-pressure chillers are thermostatic expansion valve, orifice, high-side or low-side float, and electronic expansion valve. Low-pressure chillers typically use an orifice-type or a float-type metering device.

The thermostatic expansion valve (TXV) metering device used on chillers is the same type used in other refrigeration and air conditioning systems, except that large TXVs are used to accommodate the high refrigerant flow rates of chillers. A *thermostatic expansion valve (TXV)* is a valve that uses the temperature of the refrigerant discharged from an evaporator to control the liquid refrigerant flowing into an evaporator. Chiller TXVs maintain a constant superheat of 8°F to 12°F. TXVs are used on chillers under 150 tons of cooling capacity.



Sporlan Valve Company

Thermostatic expansion valves use the refrigerant discharge temperature from an evaporator to control the amount of refrigerant entering the evaporator.

An *orifice-type metering device* is a small, fixed opening that is used as a restriction in the liquid line between the condenser and the evaporator of a refrigeration system. The flow of refrigerant through the orifice is determined by the pressure differential between the high-pressure side and low-pressure side. As the cooling load increases, condenser pressure increases, causing an increase in the pressure differential across the orifice, creating a higher refrigerant flow rate through the orifice. The amount of refrigerant allowed to enter the compressor of a chiller using an orifice-type metering device is critical. Too much refrigerant (overcharging) can cause liquid refrigerant to enter the compressor.

High-pressure-side or low-pressure-side float metering devices are used on chillers with flooded evaporators. A high-pressure-side float is located on the liquid line to the evaporator. As the cooling load increases, more refrigerant is boiled off in the evaporator. That also means that the condenser is condensing more refrigerant, so the liquid level in the float chamber increases. The float ball rises with the liquid level, allowing more liquid refrigerant to flow into the evaporator.

A chiller that utilizes a low-side float-metering device has the float located at the normal refrigerant level in the evaporator. As more refrigerant is boiled off due to an increase in load, the liquid refrigerant level will decrease. A drop in the level of the refrigerant will cause the float ball to drop, opening a valve to allow more liquid refrigerant into the evaporator from the condenser. Both types of float-type metering devices control the critical charge in a chiller.

Electronic expansion valve (EXV) metering devices are becoming the standard for reciprocating chillers. EXV devices are similar to TXVs used in other refrigeration and air conditioning equipment. The sensor for the EXV is a

thermistor mounted in the suction line from the evaporator to monitor the temperature of the refrigerant vapor. A signal is sent to the EXV to maintain a given superheat temperature. EXVs are capable of higher flow rates and are able to operate with lower condenser pressures than TXVs. The better capabilities of EXVs allow them to be used in systems with wider variations in load conditions.

Evaporators. The evaporator is the component in the chiller that transfers heat from the water to the liquid refrigerant. As the heat is absorbed, the refrigerant boils, creating a vapor that is carried to the compressor. The exchange of heat takes place in shell-and-tube evaporators that are normally of a two-pass design. The water returning to the chiller from the building is cooled and circulated back to the cooling coils in the building. **See Figure 1-16.** The water returning to the chiller is normally at a temperature of about 55°F, which is cooled to about 45°F before the water is sent back into the building. The cooled water is called chilled water and the system is a closed water system.

The evaporators used for chillers are either direct expansion evaporators or flooded evaporators. The direct expansion evaporator has a specific superheat and normally uses a TXV to control the superheat. Direct expansion evaporators are used on small chillers because of the limitations of the TXV. Flooded evaporators are more popular for large chillers but require significantly more refrigerant than direct expansion chillers. The main advantage of flooded evaporator chillers is that there is a better exchange of heat from the water to the liquid refrigerant, making the chiller more efficient to operate.

Flooded evaporators are designed to maintain a level of liquid in the shell of the evaporator. This level of liquid should cover the tube bundle at all times. Chilled water flows through the tubes.

➤ Technical Fact

EVAPORATOR SHELL-AND-TUBE HEAT EXCHANGERS

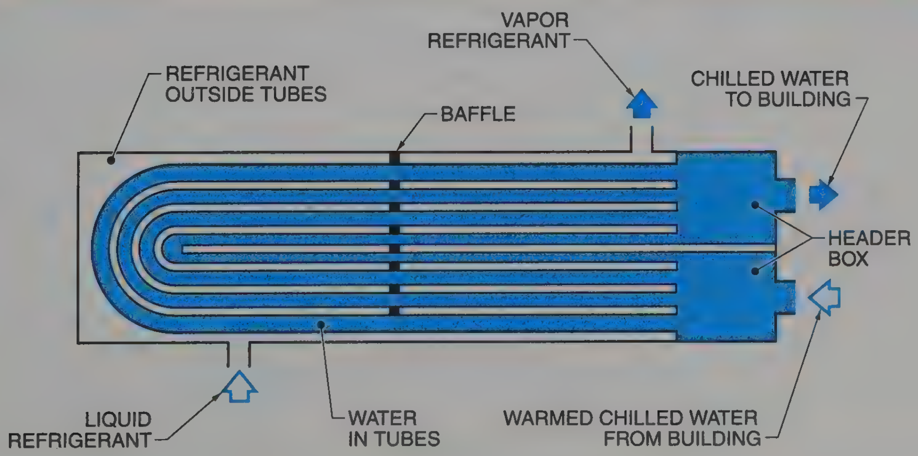


Figure 1-16. The evaporator of a chiller is the component that transfers heat from the chilled water to the liquid refrigerant.

Discussion Questions

1. How does a refrigeration system cool building spaces?
2. How do the components of a mechanical compression refrigeration system operate?
3. How does a mercury barometer measure atmospheric pressure?
4. Why does refrigerant vaporize in the evaporator of a refrigeration system?
5. How are gauge pressure and absolute pressure related?
6. How is pressure controlled in a refrigeration system?
7. Why is high-pressure refrigerant present in a refrigeration system?
8. How does a mechanical refrigeration system operate?
9. How do high- and low-pressure chillers operate?
10. How are high-pressure chiller compressors different from low-pressure compressors?
11. How does a tube-and-shell condenser operate?
12. Why is it critical to control the amount of refrigerant flowing into an evaporator with a metering device?
13. How does a shell-and-tube evaporator operate?

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REVIEW QUESTIONS

Name ______________________________ Date ______________

B 1. The second law of thermodynamics states that heat always flows from a material at a ___ temperature to a material at a ___ temperature.

A. low; high
B. high; low
C. low; constant
D. high; constant

D 2. A(n) ___ increases the temperature of, and pressure on, refrigerant vapor.

A. expansion device
B. condenser
C. orifice
D. compressor

B 3. ___ is a fluid that has a lower temperature than refrigerant.

A. Evaporator medium
B. Condensing medium
C. Compressor oil
D. Refrigerant

A 4. A(n) ___ is a heat exchanger where heat is absorbed into low-pressure refrigerant.

A. evaporator
B. condenser
C. expansion device
D. compressor

D 5. A perfect vacuum is ___.

A. 0 psi
B. 0 psig
C. 14.7 psia
D. 29.92 in. Hg

D 6. When the pressure on a liquid is increased, the boiling point of the liquid is ___.

A. eliminated
B. constant
C. decreased
D. increased

C 7. Expansion valves are located just before the ___.

A. compressor
B. orifice
C. evaporator
D. condenser

B

8. Refrigerant absorbs heat from the ____.

A. compressor oil

B. compressor motor windings

C. condenser

D. TXV value

B

9. The heat absorbed from the food inside a typical freezer is released to the air outside the freezer by the ____.

A. evaporator

B. condenser

C. capillary tube

D. orifice

A

10. The ____ is the pipe or tubing that connects the evaporator and the suction port of the compressor.

A. suction line

B. liquid line

C. capillary tube

D. expansion pipe

A

11. A high-pressure chiller condenser operates at a pressure above ____ psi.

A. 15

B. 30

C. 60

D. 90

C

12. A ____ compressor is a low-pressure compressor.

A. reciprocating

B. scroll

C. centrifugal

D. screw

D

13. A(n) ____ uses the temperature of the refrigerant discharged from an evaporator to control the liquid refrigerant flowing into the evaporator.

A. high-side float

B. orifice

C. capillary tube

D. thermostatic expansion valve

2 Safety

Servicing air conditioning and refrigeration equipment containing refrigerants requires following various EPA, company, and chemical safety standards and procedures. Safety standards and procedures include wearing approved protective clothing and using protective equipment. Additional personnel requirements include an understanding of the different danger, warning, and caution labels used with refrigerants, recovery machines, and devices.

CERTIFIED TECHNICIANS

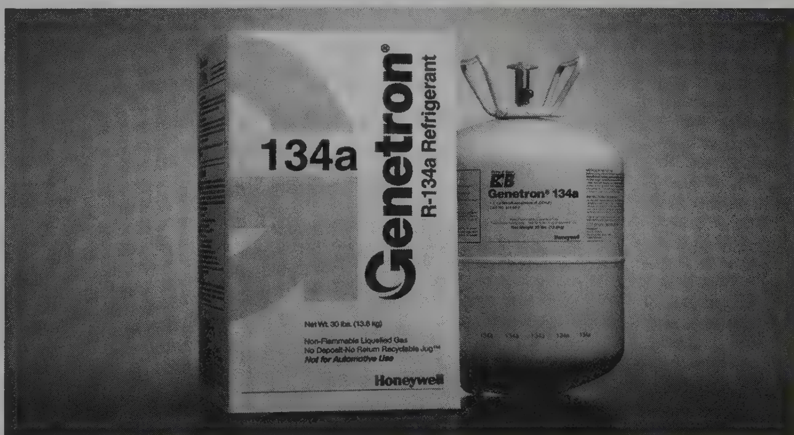
Refrigerants must be charged, recovered, or recycled only by certified technicians. A certified technician is a person who has special knowledge and training, and has passed one or more EPA-approved tests in the charging, recovery, and recycling of refrigerants for air conditioning and refrigeration systems. OSHA 29 CFR 1926.32—Definitions, Subpart C—*General Safety and Health Provisions*; and OSHA 29 CFR 1910.399—*Definitions applicable to this subpart,* provide additional information regarding the definitions of various types of technicians.

A certified technician:

- works safely with refrigerants and follows all Environmental Protection Agency (EPA), Air Conditioning and Refrigeration Institute (ARI), and company procedures and practices
- performs the appropriate task required during an accident or emergency situation, understands air conditioning and refrigeration system operation, and follows all manufacturer procedures
- understands the operation of refrigerant recovery equipment and recycling equipment, and follows all equipment manufacturer procedures
- knows how to find help from equipment manuals and manufacturer representatives
- informs other technicians and facility personnel of tasks being performed
- maintains all required computerized and written records

The Office of the Federal Register (OFR) informs citizens of their rights and obligations by providing access to the official text of federal laws, the Code of Federal Regulations (CFR), and other documents.

Technical Fact



Honeywell Chemicals

Refrigerant containers must be labeled, tagged, and marked with the appropriate hazard warning per OSHA 29 CFR 1910.1200(f)—*Labels and Other Forms of Warning.*

CODES AND STANDARDS

National, state, and local codes and standards are used to protect people and the environment from refrigerant hazards. A *code* is a regulation or minimum requirement. A *standard* is an accepted reference or practice. Codes and standards ensure that refrigerant handling equipment is built by manufacturers for safe use, and is used safely by technicians. Technicians must handle refrigerants safely and make every effort to protect people and the environment from refrigerant hazards.

SAFETY LABELS

A *safety label* is a sticker that indicates areas or tasks that can pose a hazard to personnel and/or air conditioning and refrigeration equipment. Safety labels are used on refrigerant cylinders, on air conditioning and refrigeration equipment, and are depicted in equipment manuals. Safety labels use signal words to communicate the severity of a potential hazard. The three most common signal words are danger, warning, and caution. **See Figure 2-1.**

DANGER is a signal word that is used to indicate an imminently hazardous situation which, if not avoided, will result in death or serious injury. The information indicated by a danger signal word indicates the most extreme type of potentially hazardous situation, and must be followed.

WARNING is a signal word that is used to indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury. The information indicated by a warning signal word indicates a potentially hazardous situation and must be followed.

CAUTION is a signal word that is used to indicate a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. The information indicated by a caution signal word indicates a potentially hazardous situation that may cause injury and/or equipment damage. A caution signal word also warns of possible hazards due to unsafe work practices.

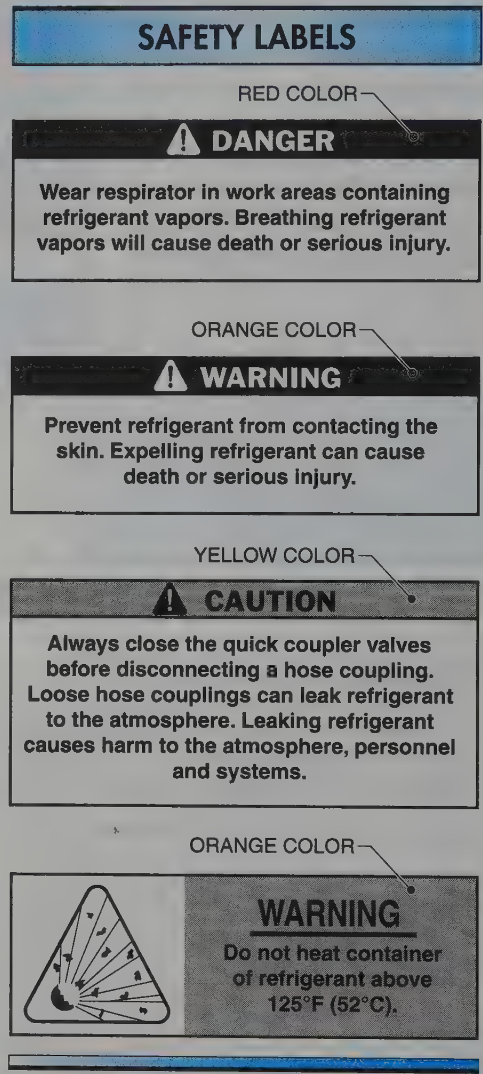


Figure 2-1. Safety labels are used to indicate hazardous situations with different degrees of likelihood of death or injury to personnel.

Other symbols and signal words may appear with the danger, warning, and caution signal words used by manufacturers. ANSI Z535.4, *Product Safety Signs and Labels,* provides additional information concerning safety labels. Additional signal words may be used alone or in combination on safety

labels. ***EXPLOSION WARNING*** is a signal word that is used to indicate locations and conditions where exploding parts may cause death or serious personal injury if proper precautions and procedures are not followed.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) is gear worn by technicians to reduce the possibility of injury when charging, recovering, or recycling refrigerants. Personal protective equipment must be worn when handling refrigerants or refrigerant cylinders. All personal protective equipment must meet OSHA Standard Part 1910, Subpart I–*Personal Protective Equipment* (1910.132 through 1910.138), applicable ANSI standards, and other safety mandates. Personal protective equipment includes protective clothing, head protection, eye protection, ear protection, hand protection, foot protection, back protection, and respiratory protection. **See Figure 2-2.**

Protective Clothing

Protective clothing is clothing made of durable material such as denim and provides protection from contact with sharp objects, cold equipment, and harmful materials. Protective clothing should be snug, yet allow ample movement. Soiled protective clothing should be washed to reduce the flammability hazard.

Coveralls and coveralls with hoods made from chemical-resistant fibers provide protection from refrigerants. The chemical-resistant fibers are sometimes coated with SARANEX® to provide protection against a broader range of refrigerants and chemicals. Chemical-resistant aprons can also be used when working with refrigerants. Chemical-resistant aprons are typically made of materials such as rubber, Silver Shield™, or neoprene.

PPE is provided by the employer and worn by technicians. The PPE must be appropriate for the work and give adequate protection.

Technical Fact

Never allow liquid refrigerant to contact skin. Never siphon refrigerant with mouth. Always use safety goggles and gloves when working with liquid refrigerant.

Technical Fact

PERSONAL PROTECTIVE EQUIPMENT

Figure 2-2. Personal protective equipment is used when working with refrigerants to reduce the possibility of injury.

Head Protection

A *protective helmet* is a hat that is used in work areas to prevent injury from the impact of falling and flying objects. Protective helmets resist penetration and absorb impact force. Protective helmet shells are made of durable, lightweight materials. A shock-absorbing lining consists of crown straps and a headband that keeps the shell away from the head to provide ventilation. **See Figure 2-3.**

PROTECTIVE HELMETS

North Safety Products

Class	Use
A	General service, limited voltage protection
B	Utility service, high voltage protection
C	Special service, no voltage protection

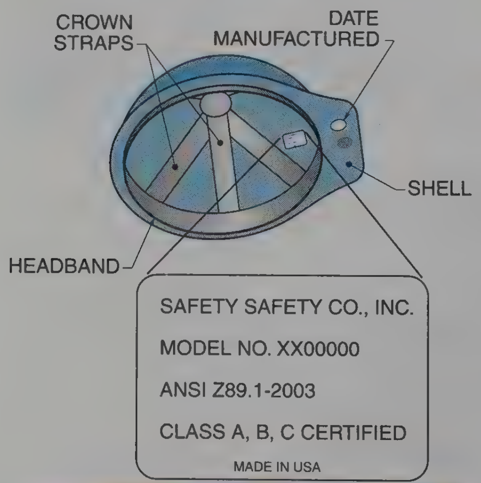


Figure 2-3. Protective helmets are identified by the class of protection against hazardous conditions that the helmet provides.

Eye Protection

Eye protection is devices that must be worn to prevent eye or face injuries caused by flying particles or refrigerant spray. Eye protection must comply with OSHA 29 CFR 1910.133–*Eye and Face Protection*. Eye protection standards are also specified in ANSI Z87.1, *Occupational and Educational Personal Eye and Face Protection Devices*. Eye protection includes safety glasses, goggles, and face shields. **See Figure 2-4.**

Safety glasses are an eye protection device with special impact-resistant glass or plastic lenses, reinforced frames, and possibly side shields. The plastic frames are designed to keep the lenses secured if an impact occurs. Side shields provide additional protection from flying objects. *Goggles* are an eye protection device with a flexible frame that is secured on the face with an elastic headband. Goggles fit snugly against the face to seal the areas around the eyes, and may be used over prescription glasses. Goggles protect against small flying particles (solid or liquid). A *face shield* is an eye and face protection device that covers the entire face with a plastic shield and is used for protection from flying objects or splashing refrigerants. Face shields are recommended any time a technician is working with or around refrigerants.

Ear Protection

Power tools, HVAC equipment, and refrigerant-handling equipment can produce excessive noise levels. Technicians subjected to excessive noise levels may develop hearing loss over time. The severity of hearing loss depends on the intensity and duration of exposure. Noise intensity is expressed in decibels. A *decibel (dB)* is a unit of measure used to express the relative intensity of sound. Ear protection is worn to prevent hearing loss.

To determine the approximate noise reduction of ear protection, 7 dB is subtracted from the NRR.

▶ Technical Fact

Ear protection includes earplugs and earmuffs. **See Figure 2-5.** An *earplug* is an ear protection device made of moldable rubber, foam, or plastic that is inserted into the ear canal. An *earmuff* is an ear protection device worn over the ears. A tight seal around an earmuff is required for proper protection. Ear protection devices are assigned a noise reduction rating (NRR) number based on the amount of noise reduced.

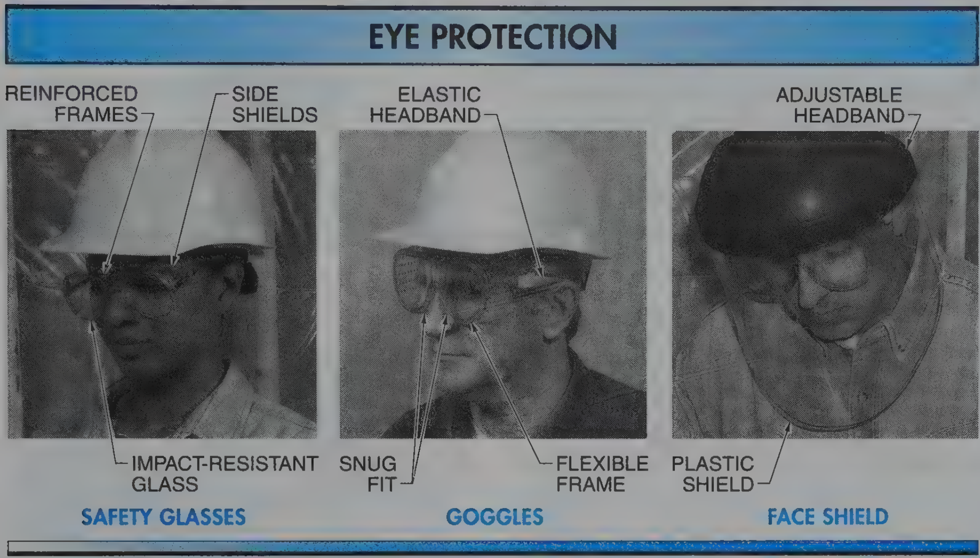


Figure 2-4. Eye protection must be worn to prevent eye or face injuries caused by flying objects or escaping refrigerants.

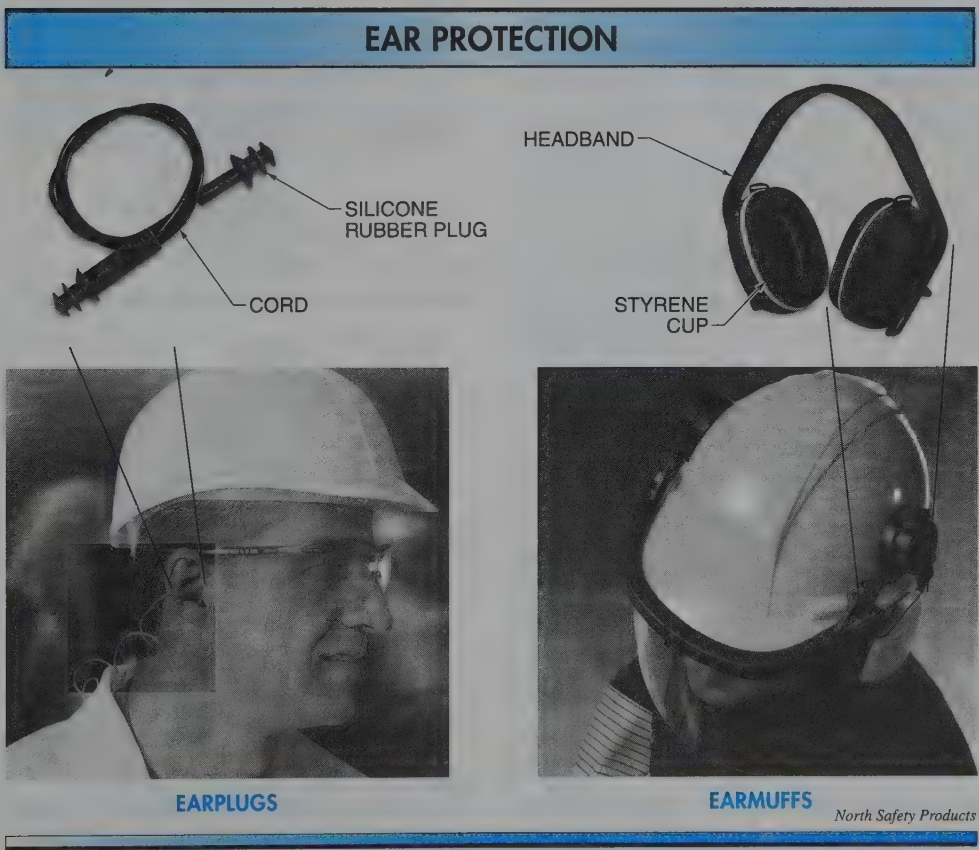


Figure 2-5. Ear protection is worn to prevent technician hearing loss caused by power tools, HVAC equipment, or refrigerant-handling equipment.

Hand Protection

Hand protection is required to prevent injuries to hands such as cuts from equipment or frostbite from refrigerants. The appropriate hand protection is determined by the duration, frequency, and degree of the hazard to the hands. *Chemical gloves* are gloves made of rubber (butyl), Silver Shield™, or neoprene and are used to provide protection when handling refrigerants. Gloves made of other materials may be required when handling compressor oils. OSHA 29 CFR 1910.138–*Hand Protection*, Subparts (a) and (b), provide additional information regarding hand protection.

Foot Protection

Foot injuries are typically caused by objects falling less than 4′ and having an average weight less than 65 lb. Safety shoes with reinforced steel toes protect against injuries caused by compression and impact. Technicians working with refrigerants should wear boot covers or rubber overshoes. Boot covers made of Silver Shield™ or overshoes made of rubber protect the feet of a technician from frostbite caused by refrigerants. Protective footwear must comply with ANSI Z41-1991, *Personal Protection–Protective Footwear*. OSHA 29 CFR 1910.136–*Occupational Foot Protection*, provides additional information regarding foot protection.

The major cause of death from refrigerant accidents is oxygen deprivation.

Technical Fact

Respirators

A *respirator* is a device worn by technicians to protect against the inhalation of potentially hazardous refrigerant vapors. Respirators are categorized into two principal types, air-purifying and air-supplied. **See Figure 2-6.** Air-purifying respirators remove contaminants from the ambient air. Air-supplied respirators provide air from a source other than the surrounding atmosphere. OSHA 29 CFR 1910.134–*Respiratory Protection*, requires employers to provide respirators when necessary to protect the health of an employee.

Scott Health and Safety

Figure 2-6. Respirators are selected for the specific contaminants and refrigerant present in the working area atmosphere.

LOCKOUT/TAGOUT

Lockout is the process of removing the source of electrical power and installing a lock that prevents the power from being turned ON. *Tagout* is the process of placing a danger tag on the source of electrical power, which indicates that the equipment may not be operated until the lock and/or danger tag is removed. **See Figure 2-7.**

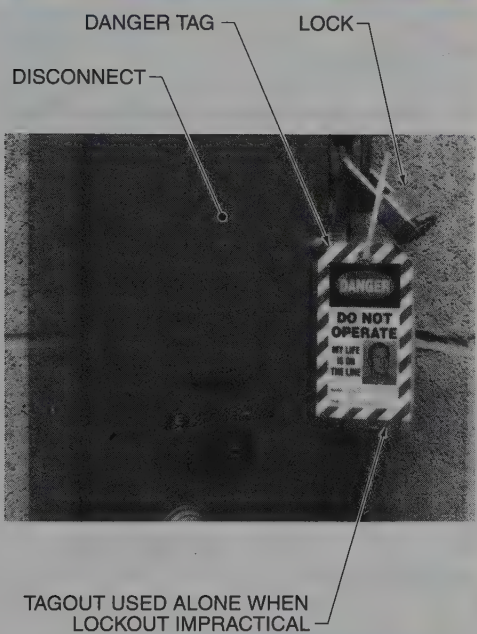
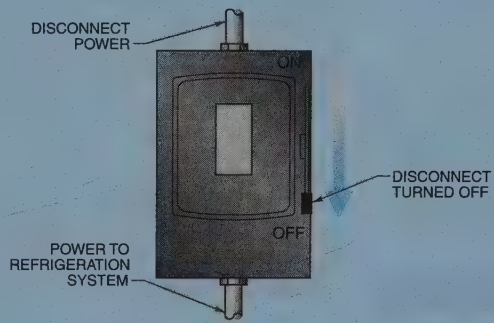


Figure 2-7. Lockouts and tagouts are applied to air conditioning and refrigeration equipment to prevent operation during certain servicing procedures.

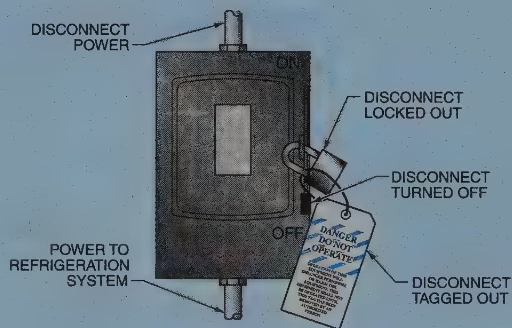
A danger tag has the same importance and purpose as a lock. Danger tags are used alone only when a lock does not fit the disconnect device. A danger tag shall be attached at the disconnect device with a tag tie or equivalent and shall have space for the name of the technician, craft, and other company-required information.

Equipment Lockout/Tagout Procedure

1. Notify all affected persons that a lockout/tagout is required. Notification should include the reason for the lockout/tagout and the expected duration.
2. When the equipment is operating, shut down the equipment using normal procedures.
3. Apply the energy-isolating device or devices so that the equipment is isolated from all energy sources. Stored energy, such as in springs, elevated machine members, capacitors, and pneumatic lines, must be dissipated or restrained by blocking, discharging, or other appropriate methods.



4. Apply the lockout and/or tagout to the energy-isolating device or devices with assigned locks and/or danger tags.



5. After ensuring that personnel are not exposed, operate the normal operating controls to verify that the equipment is inoperable and that all energy sources have been isolated.
6. Inspect and test the equipment with the appropriate test instruments to verify that all energy sources are disconnected. Multiphase electrical power requires that each phase be tested. The equipment is now locked out and/or tagged out.

Note: A lockout/tagout must not be removed by any person other than the authorized person who installed the lockout/tagout, except in an emergency. In an emergency, only authorized supervisory personnel may remove a lockout/tagout and only upon notification of the authorized person who installed the lockout/tagout.

REFRIGERANT SAFETY

All refrigerants, regardless of quantity, must be handled with care. Refrigerants are dangerous when allowed to leak out of sealed systems and mix with air.

Refrigerants and refrigerant containers are also dangerous when exposed to open flames or high temperatures. Most refrigerants boil at very low temperatures and, when heated, refrigerant compounds change chemically, allowing toxic gases to be generated. Always refer to the manufacturer-recommended safety procedures when handling refrigerants used in air conditioning and refrigeration systems. Refrigerant safety rules include the following:

- Store refrigerants in a clean, dry area out of direct sunlight. Never heat refrigerant containers above 125°F.
- Comply with fire regulations concerning storage quantities, types of approved containers, and proper labeling.
- Never allow a refrigerant to come in contact with skin, causing frostbite. Always use gloves and face protection.
- Never allow refrigerant vapors to build up in a low or confined area. Fluorocarbon refrigerants are heavier than air and can cause suffocation, heart irregularities, or unconsciousness due to lack of oxygen if exposure exceeds acceptable levels.
- Read the label on the refrigerant cylinder to identify contents and verify color coding.
- Never use oxygen or compressed air to pressurize appliances to check for leaks because, when mixed with compressor oil, oxygen or compressed air can explode. **See Figure 2-8.**
- Clean up oil spills immediately.

Refrigerant labels are placed on refrigerant cylinders to identify gross weight.

▶ Technical Fact

Refrigerant vapors or mists can cause heart irregularities or unconsciousness.

▶ Technical Fact

ASHRAE Standard 15 requires an equipment room refrigerant monitor to be used with all refrigerants; the monitor can also be used as a leak detector. ASHRAE Standard 15 also requires a sensor and alarm for all A1 refrigerants to sense for oxygen deprivation.

▶ Technical Fact

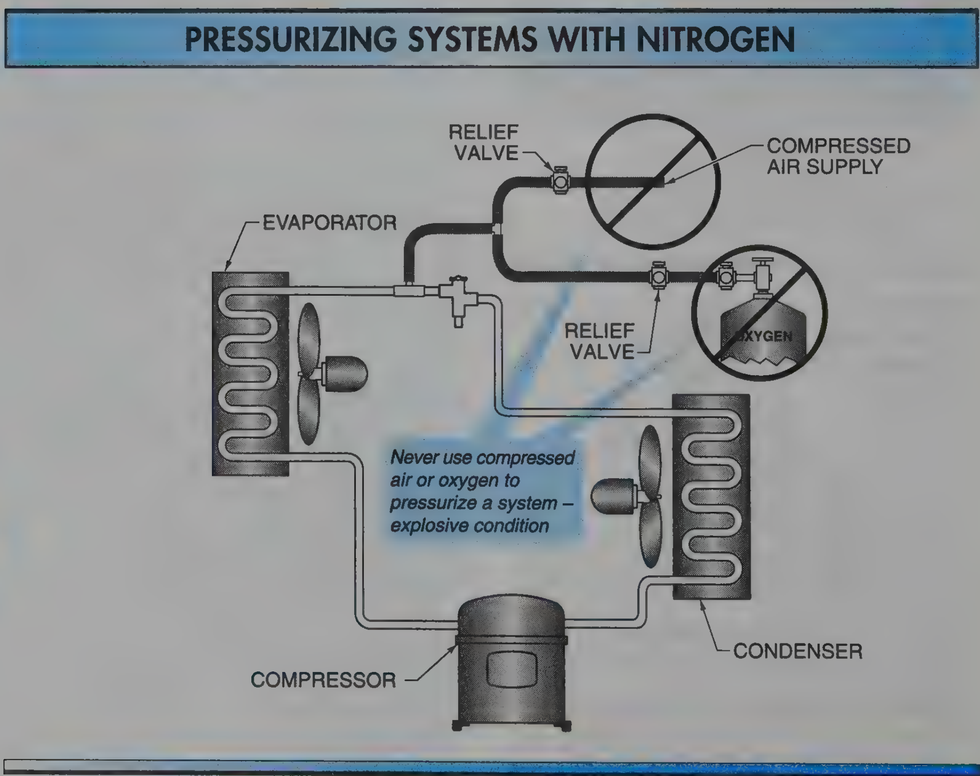


Figure 2-8. Compressed air or oxygen used to pressurize a system creates an explosive condition.

The ideal refrigerant is environmentally friendly, nonflammable, nontoxic, and able to perform as intended in the refrigeration system. Refrigerants are not completely safe, but refrigerants can be used safely.

Section 8 of ANSI/ASHRAE Standard 34-2004, *Designation and Safety Classifications of Refrigerants,* identifies the requirements for applying for designations and safety classifications (safety groups) for refrigerants, including blends. **See Figure 2-9.** A1 refrigerants are the safest, and B3 refrigerants are the most toxic and flammable. Letters A or B indicate level of toxicity (B being higher), and numbers 1, 2, and 3 indicate levels of flammability (3 being the highest). R-11, R-12, R-22, R-500, R-502, and R-134a are classified as A1 refrigerants and R-123 is classified as a B1 refrigerant.

ANSI/ASHRAE 34—Refrigerant Safety Groups

	Lower Toxicity	Higher Toxicity
No Flame Propagation	A1	B1
Lower Flammability	A2	B2
Higher Flammability	A3	B3

Figure 2-9. Refrigerants are classified by ANSI/ASHRAE 34-2001 into safety groups.

An oxygen-deprivation sensor is required to detect low oxygen levels in work areas. Typically, oxygen alarms will alarm at 19.5% or less by volume. Monitoring rooms for the right amount of oxygen is required for all refrigerants. A self-contained breathing apparatus (SCBA) must be worn if a large leak has occurred. When an SCBA is not available, technicians must ventilate the area or vacate the area immediately.

To obtain more information on any refrigerant, a safety data sheet (SDS) can be obtained from the manufacturer. When working with any refrigerant, the technician must review the SDS for that refrigerant.

Safety Data Sheet

A *safety data sheet (SDS)* is a printed document used to relay hazardous material information from the manufacturer, importer, or distributor to the technician. **See Figure 2-10.** All hazardous materials used in a facility or at a job site must be inventoried and have an SDS. SDS files must be kept up to date (check with manufacturer regularly for changes) and readily available to all personnel. Refrigerant manufacturers, distributors, and importers must develop SDSs for each refrigerant sold. If two or more SDSs on the same refrigerant are found, the latest version is used. SDSs have no prescribed format. Formats provided in ANSI Z400.1, *Hazardous Industrial Chemicals Safety Data Sheet Preparation,* are commonly used. An SDS includes the following:

- manufacturer and product information
- hazardous ingredients/identity information
- physical/chemical characteristics
- fire and explosion hazard data
- reactivity and health hazard data
- precautions for safe handling and types of PPE required
- control measures
- regulatory information

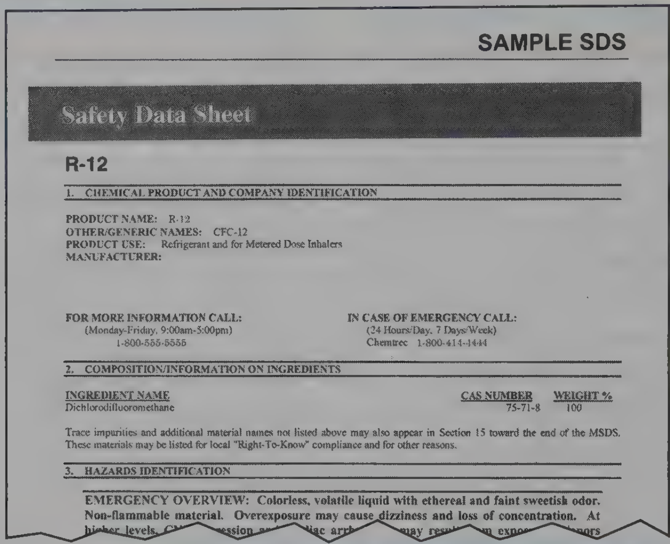
R-22 refrigerant has low toxicity, but is known to cause oxygen deprivation (asphyxia).

Technical Fact

Air conditioning or refrigeration systems with an R-134a refrigerant charge are leak checked with pressurized nitrogen.

Technical Fact

SAFETY DATA SHEETS


SAMPLE SDS

Safety Data Sheet

R-12

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: R-12
OTHER/GENERIC NAMES: CFC-12
PRODUCT USE: Refrigerant and for Metered Dose Inhalers
MANUFACTURER:

FOR MORE INFORMATION CALL:
(Monday-Friday, 9:00am-5:00pm)
1-800-555-5555

IN CASE OF EMERGENCY CALL:
(24 Hours/Day, 7 Days/Week)
Chemtrec 1-800-414-4444

2. COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENT NAME	CAS NUMBER	WEIGHT %
Dichlorodifluoromethane	75-71-8	100

Trace impurities and additional material names not listed above may also appear in Section 15 toward the end of the MSDS. These materials may be listed for local "Right-To-Know" compliance and for other reasons.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Colorless, volatile liquid with ethereal and faint sweetish odor. Non-flammable material. Overexposure may cause dizziness and loss of concentration. At

Figure 2-10. An SDS provides refrigerant hazard information such as proper handling, emergency control measures, and first-aid procedures.

Safety Data Sheets

Chemicals can pose a wide range of hazards, from mild irritation to possible death. OSHA's Hazard Communication Standard is designed to ensure that workers and employers have information about these hazards and can establish appropriate protective measures. One important source for this information is the safety data sheet (SDS).

The SDS is a technician's primary tool for finding information about the chemicals technicians work with. SDSs can be in any format, but OSHA has established certain requirements for SDSs. First of all, they must be in English.

Second, all SDSs must be readily accessible during each work shift. If a technician or coworkers must travel between work locations, SDSs may be kept at a central location, but the SDSs must still be accessible.

Chemical manufacturers and importers are required to obtain or develop an SDS for each hazardous chemical they produce or import. Distributors are responsible for ensuring that their customers are provided a copy of these SDSs. Employers must receive and retain an SDS for each hazardous chemical that they use.

While SDSs need not be physically attached to a shipment, they must accompany or precede the shipment. If they do not, the employer must obtain one from the chemical manufacturer, importer, or distributor as soon as possible. The same is true if an SDS arrives that is incomplete or unclear.

Technicians must read a chemical's SDS before using the chemical to find out what safety precautions are needed. A certain chemical may not be compatible with other chemicals in use. Technicians may need to wear a respirator for protection from a chemical's effects. Technicians may need to be careful about the ambient temperature the chemical is used in. The information on an MSDS will help a technician determine what safety measures are needed that could save valuable time in the event of an accident.

Occupational Safety and Health Administration

NFPA Hazard Signal

Refrigerant containers must be labeled, tagged, and marked with appropriate hazard warnings per OSHA 29 CFR 1910.1200(f)–*Labels and Other Forms of Warning.* Refrigerants stored in different containers than originally supplied from the manufacturer must also be properly labeled. Unlabeled containers pose a safety hazard since technicians are not provided with content information and warnings. All container labels must include basic Right to Know (RTK) information. **See Figure 2-11.**

ASHRAE STANDARD 15

The *American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)* is an organization that advances the arts and sciences of heating, ventilation, air conditioning, and refrigeration systems.

The purpose of ASHRAE Standard 15, *Safety Standard for Refrigeration Systems,* is to specify safe design,

construction, installation, and operation of refrigeration systems.

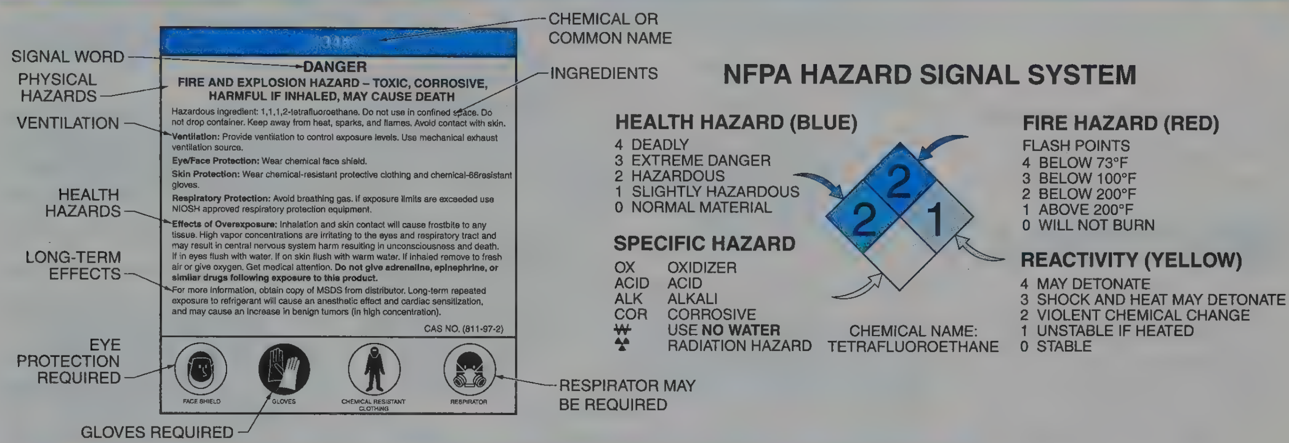
The code applies to:

- monitors
- alarms
- ventilation
- purge venting
- breathing apparatus

Disposable cylinders are used for virgin refrigerant. Disposable cylinders should never be used to recover refrigerant. When scrapping a refrigerant cylinder, the internal pressure must be at least 0 psi (atmospheric pressure). Cylinders should never be stored by an open flame or in very hot areas.

▶ Technical Fact

NFPA HAZARD SIGNAL AND RTK LABEL



RTK LABEL

Identification of Health Hazard Color Code: BLUE		Identification of Flammability Color Code: RED		Identification of Reactivity (Stability) Color Code: YELLOW	
Signal	**Type of Possible Injury**	**Signal**	**Susceptibility of Materials to Burning**	**Signal**	**Susceptibility to Release of Energy**
4	Materials that on very short exposure could cause death or major residual injury	4	Materials that will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or that are readily dispersed in air and that will burn readily	4	Materials that in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures
3	Materials that on short exposure could cause serious temporary or residual injury	3	Liquids and solids that can be ignited under almost all ambient temperature conditions	3	Materials that in themselves are capable of detonation or explosive decomposition or reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water
2	Materials that on intense or continued but not chronic exposure could cause temporary incapacitation or possible residual injury	2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur	2	Materials that readily undergo violent chemical change at elevated temperatures and pressures or which react violently with water or which may form explosive mixtures with water
1	Materials that on exposure would cause irritation but only minor residual injury	1	Materials that must be preheated before ignition can occur	1	Materials that in themselves are normally stable, but which can become unstable at elevated temperatures and pressures
0	Materials that on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material	0	Materials that will not burn	0	Materials that in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water

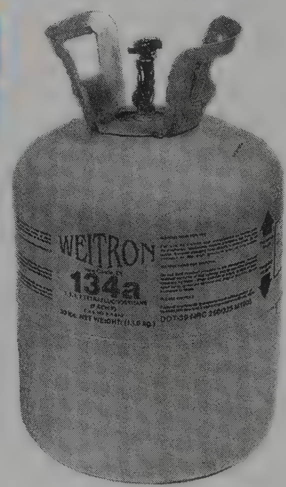


Figure 2-11. The NFPA Hazard Signal System provides quick-reference information regarding hazardous materials (refrigerants).

Never overfill a refrigerant storage cylinder. The internal pressure of cylinders will rise when heated or when placed in sunny areas, which can cause an explosion. Fill refrigerant storage cylinders only to 80% capacity. Capacity can be determined by using mechanical float devices, electronic shut-off devices, or weight.

▶ Technical Fact

Pressure relief valves must never be installed in series.

▶ Technical Fact

DOT REUSABLE CONTAINER SAFETY

A *DOT reusable container* is an empty container that is shipped to a facility where the container will be filled, labeled with a DOT classification tag, and shipped again. Capacities of DOT containers are measured in pounds of water. DOT container safety rules include the following:

- Use approved DOT containers to store refrigerants. **See Figure 2-12.**
- Check refrigerant containers for a current (within 5 yr) hydrostatic test date before use.
- Check refrigerant containers for dents, gouges, cuts, or other imperfections that make the container unsafe for use.
- Verify all hose connections are tight before transferring refrigerants to or from containers.
- Replace refrigerant cylinder valve outlet caps when task is completed.
- Make sure all refrigerant containers are clearly labeled with the chemical name.
- Never refill disposable cylinders.
- Never apply an open flame or live steam to a refrigerant cylinder.

Heating a refrigerant storage container or recovery cylinder with an open flame or steam can cause an explosion.

▶ Technical Fact

AIR CONDITIONING AND REFRIGERATION SYSTEM SAFETY PRECAUTIONS

Technicians must develop safety habits to prevent personal injury, injury to others, and damage to appliances and equipment. Safety procedures vary depending on the type and size of the equipment. The following are basic safety rules that are common for all air conditioning and refrigeration systems:

- Only certified technicians must handle refrigerants.
- Wear approved PPE at all times.
- Use the proper tool for the job.
- Precheck all servicing equipment for hazards.
- Never enter a work area that has refrigerant vapors without adequate ventilation or a respirator.
- Rupture discs and purges must be vented into a storage container or outdoors.
- To determine the safe pressure for leak testing a system, technicians must use the low-side test pressure data-plate value. To verify the maximum allowable system test pressure, the design pressure on the nameplate of the system is checked.
- Never cut or weld any refrigerant line while refrigerant is in the system or unit.

Using Nitrogen

Whenever dry nitrogen from a portable cylinder is used to pressurize an appliance, a relief valve must be in the downstream line from the pressure regulator. When more than one relief valve is in use, the valves must not be in series. If corrosion is present in the relief valve, the relief valve must be replaced.

REFRIGERANT DOCUMENTATION FORMS

To comply with Section 608 of the Clean Air Act (CAA) regarding refrigerants, accurate recordkeeping and quality documentation are critical. For a technician to comply with EPA regulations, documentation of work performed on a system and of refrigerants cannot be vague or incomplete.

Technicians and facility owners must be aware of the difference between work orders and refrigerant documents. A *work order* is a form used for accounting purposes. A *refrigerant document* is a form used for proving innocence in the face of an accusation of misconduct. **See Figure 2-13.** EPA 40 CFR Part 82, Subpart F–*Recordkeeping Requirements,* provides additional information on recordkeeping.

Always ship refrigerant cylinders in the upright position.

Technical Fact

Figure 2-12. Refrigerant containers used for refrigerant storage and shipping must be approved by the Department of Transportation (DOT).

REFRIGERANT DOCUMENTATION FORM—USAGE

REFRIGERANT USAGE

Job #: ______

Unit Name: ______ Unit Location: ______

Equipment Description: ______

Refrigerant Type: ______ Oil Type: ______

Filter Changed (Y/N): ______ Amount of Oil Removed: ______

Amount Recovered: ______ Recovery Unit: ______

Why Recovered: ______ Serial #: ______

Recovered Sent to: ______

Amount Recycled: ______ Recycling Unit: ______

Why Recycled: ______ Serial #: ______

Re[illegible] sent to:

Figure 2-13. Documentation forms provide a written record of refrigerant usage and disposal.

Discussion Questions

1. Why must a technician be certified to handle refrigerants?
2. What is the difference between a code and a standard?
3. What is the function of a safety label?
4. What personal protective equipment is commonly required when working with refrigerants?
5. How are the face and eyes protected from spraying or splashing refrigerants?
6. How is the appropriate hand protection for working with refrigerants determined?
7. Why is danger tag used in place of lockout in certain circumstances?
8. What potential hazards are present when working with refrigerants?
9. What information do the ANSI/ASHRAE 34 safety groups provide?
10. What information is included on an MSDS?
11. Why must all refrigerant containers be labeled?
12. How are refrigerant containers scrutinized and prepared for shipping?
13. Why do air conditioning and refrigeration safety procedures vary?
14. How is dry nitrogen used safely with air conditioning and refrigeration systems?
15. Why is accurate refrigerant-specific documentation important?

Digital Resources

ATPeResources.com/QuickLinks
Access Code: 827160

REVIEW QUESTIONS

Name ______________________________ Date ______________

______________ 1. A(n) ___ is a person who has passed an approved EPA test in the charging, recovery, and recycling of refrigerants.

A. apprentice
B. qualified person
C. competent person
D. certified technician

______________ 2. The ___ signal word indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

A. danger
B. warning
C. caution
D. important

______________ 3. All personal protective equipment must meet ___ standards, ANSI standards, and safety mandates.

A. EPA
B. OSHA
C. NEC
D. NFPA

______________ 4. ___ provide technicians protection from the impact of falling or flying objects.

A. Chemical gloves
B. Eye protection
C. Ear plugs
D. Protective helmets

______________ 5. Ear protection devices are assigned a ___ number based on the amount of noise reduction.

A. total sound level (TSL)
B. decibel blocking (dB)
C. noise reduction rating (NRR)
D. serial

______________ 6. A ___ is attached to a disconnect device and has space for the name of a technician, craft, and other company required information.

A. MSDS
B. lock
C. danger tag
D. RTK label

______________ 7. Refrigerant containers must not be heated above ___°F.

A. 85
B. 125
C. 165
D. 212

_______________ **8.** In most refrigerant accidents where death occurs, the major cause is ___.

A. toxic poisoning
B. oxygen deprivation
C. refrigerant burning
D. heart failure

_______________ **9.** In the ANSI/ASHRAE 34 safety groups classification, ___ is the safest category of refrigerants.

A. A1
B. A3
C. B1
D. B3

_______________ **10.** A ___ is a printed document used to relay hazardous material information from the manufacturer to a technician.

A. straight bill of lading
B. Right to Know sheet
C. Material Safety Data Sheet
D. refrigerant usage form

_______________ **11.** An NFPA ___ signal indicates health hazards, fire hazards, and reactivity of a refrigerant or chemical.

A. safety
B. warning
C. caution
D. hazard

_______________ **12.** Capacities of DOT containers are measured in ___.

A. pounds of water
B. gallons
C. inches of mercury
D. liters

_______________ **13.** The main reason why a technician must never heat a refrigerant storage container or recovery cylinder with an open flame is that ___.

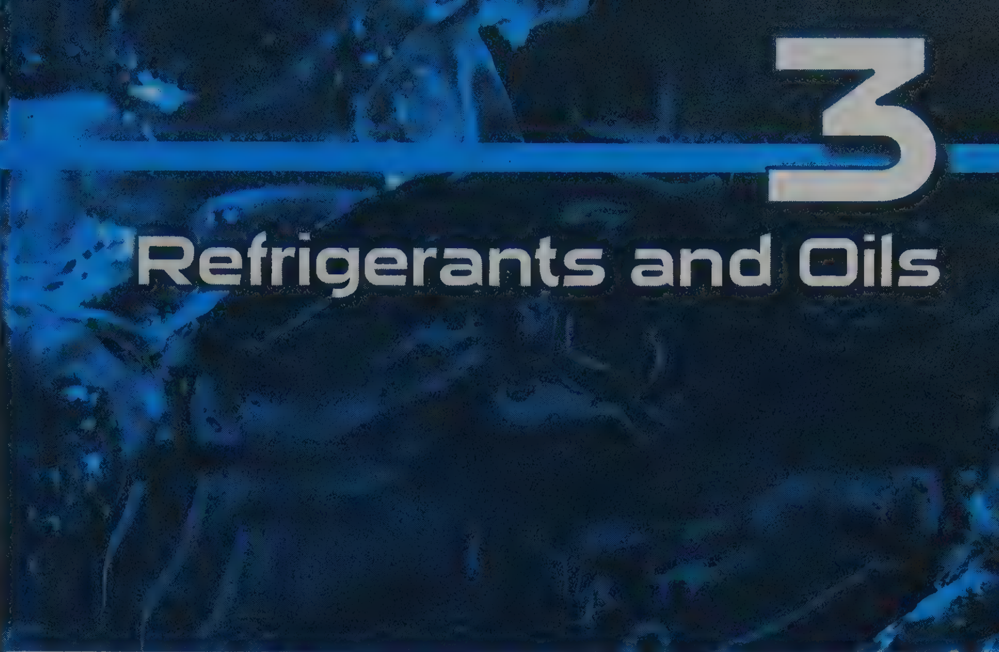
A. it can result in venting refrigerant to the atmosphere
B. the cylinder may explode, seriously injuring people in the vicinity
C. the cylinder could be damaged, rendering it unusable until repaired
D. the refrigerant in the cylinder may decompose, forming a toxic material

_______________ **14.** Rupture discs and system purges must be vented into a storage container or ___.

A. back into the system
B. another system
C. outdoors
D. recovery machine

_______________ **15.** A ___ is a form used for proving innocence in the face of an accusation of misconduct.

A. refrigerant document
B. work order
C. Material Safety Data Sheet
D. hazard signal



3 Refrigerants and Oils

Refrigerants are named according to their molecular makeup. Refrigerants are made of multiple molecules or are refrigerant blends that are mixtures of refrigerants. Mixtures can behave like a single new refrigerant or exhibit the independent behaviors of the individual refrigerants that make up the mixture. Refrigerants are classified by the operating pressures at which they are used in a system or by the refrigerant's ability to harm the environment. Because refrigerants are regulated by the EPA, many new environmentally safe refrigerants are being created as substitutes. Lubricating oils used in systems must be compatible with the refrigerant in the system.

REFRIGERANT HISTORY

The first refrigerants were fluorocarbon refrigerants developed in the 1920s. CFC-12 was the first commercially available refrigerant and was introduced in 1930, with CFC-11 being developed in 1932. The first HCFC refrigerant developed was HCFC-22, which was developed in 1936 and became popular for mass-produced air conditioning equipment. R-500, the first refrigerant blend, was introduced in 1950; R-502, the second refrigerant blend, was created in 1962. The newest refrigerants developed for mass production are the HFC refrigerants such as HFC-134a.

REFRIGERANTS

A *refrigerant* is a fluid (liquid or vapor) in a refrigeration system that accomplishes heat transfer by absorbing heat (evaporator) to change state from a liquid to a vapor or giving up heat (condenser) to change state from a vapor to a liquid. Refrigerants change from a liquid to a vapor at low temperatures and pressures, and change from a vapor to a liquid at high temperatures and pressures. There is no universal refrigerant that can be used with all types of equipment and in all types of systems. **See Figure 3-1.**

MOLECULAR MAKEUP

Most refrigerants used today were derived from methane or ethane molecules. Methane and ethane are called hydrocarbons because their molecules consist of hydrogen and carbon. Halogens such as fluorine and chlorine were used to replace the hydrogen atoms to form a group of refrigerants called halocarbons. Fluorocarbon is the general term given to halocarbon refrigerants that use fluorine. CFC, HCFC, and HFC refrigerants are all considered fluorocarbon refrigerants. **See Figure 3-2.**

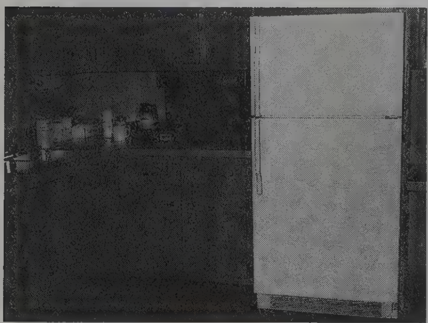
Ozone depletion potential (ODP) is a number given to refrigerants to represent the relative ozone depletion potential of a refrigerant. *Global warming potential (GWP)* is a number given to refrigerants to represent the relative global warming potential of a refrigerant (refrigerants are considered greenhouse gases). ODP and GWP numbers reflect the potential danger to the environment from individual refrigerants. The way in which refrigerants are chemically structured has created the categories of refrigerants known as CFCs, HCFCs, HFCs, and PFCs.

Chlorofluorocarbons (CFCs)

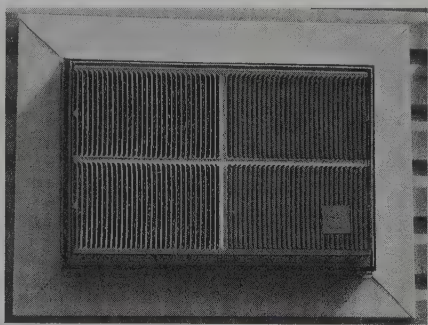
Chlorofluorocarbon (CFC) refrigerant is a refrigerant that consists of chlorine, fluorine, and carbon. For over 50 years, CFC refrigerants were the most widely used refrigerants and were thought of as miracle substances. CFC refrigerants are stable, nonflammable, low in toxicity, and inexpensive to produce.

> *By 1963, the annual sales of R-12, R-11, R-22, R-114, and R-113 CFC refrigerants were 372 million pounds.*
>
> **Technical Fact**

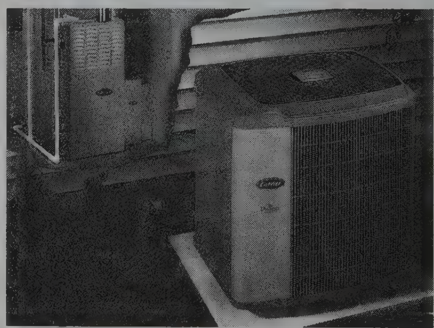
REFRIGERANT APPLICATIONS



REFRIGERATOR
TYPE I
(SMALL APPLIANCES)

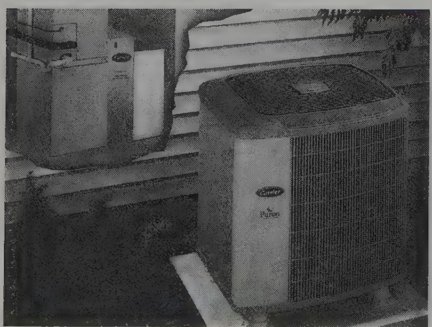


WINDOW AIR CONDITIONER
TYPE I
(SMALL APPLIANCES)



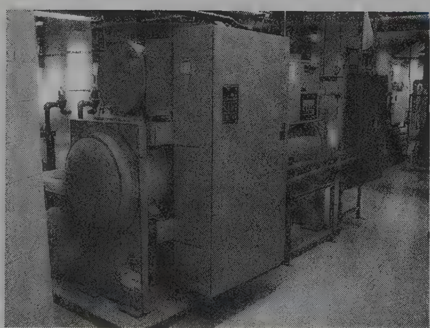
Carrier Corporation

CENTRAL AIR CONDITIONER
TYPE II
(HIGH-PRESSURE APPLIANCES)



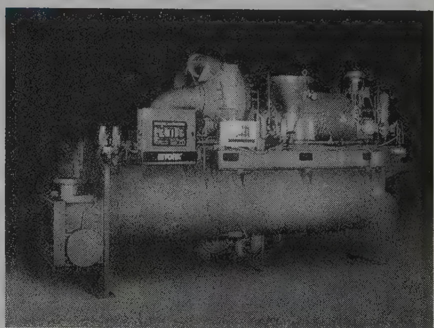
Carrier Corporation

HEAT PUMP
TYPE II
(HIGH-PRESSURE APPLIANCES)



McQuay International

WATER-COOLED CHILLER
TYPE III
(LOW-PRESSURE APPLIANCES)



York International Corp.

WATER-COOLED CHILLER
TYPE III
(LOW-PRESSURE APPLIANCES)

Figure 3-1. Because of the many types of air conditioning and refrigeration systems, many types of refrigerants are used.

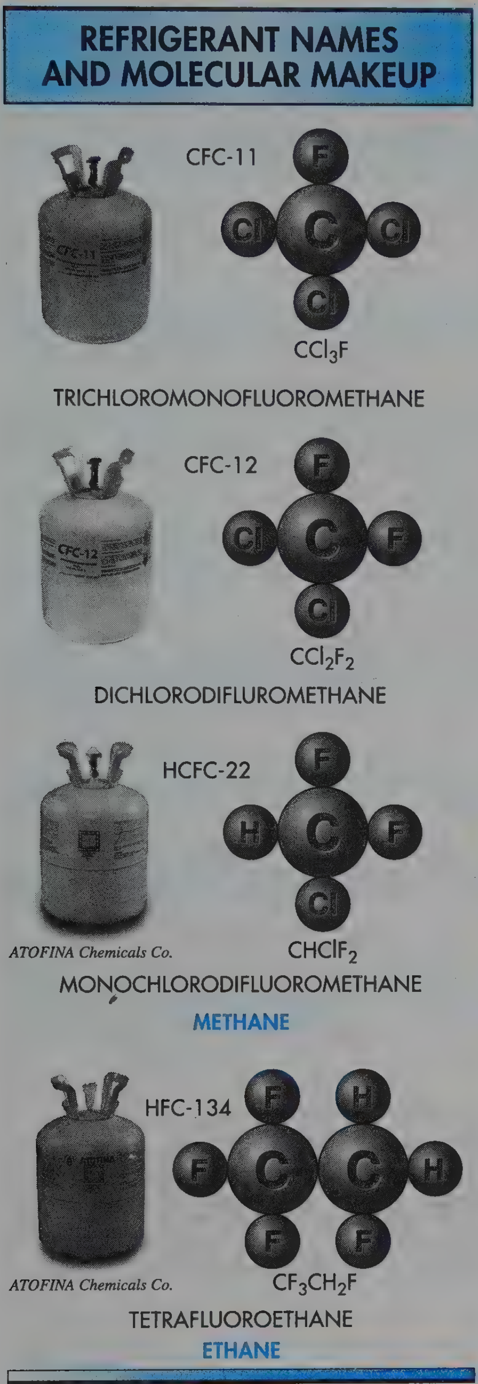


Figure 3-2. CFC, HCFC, and HFC are halocarbon refrigerants that contain fluorine and therefore are called fluorocarbon refrigerants.

However, scientific research considers CFC refrigerants to be the most hazardous refrigerants to the environment. CFC refrigerants have an atmospheric lifetime that is long enough to allow the refrigerant to be transported by winds into the stratosphere. CFCs contain chlorine, which is the element responsible for destroying the ozone layer. Because CFC refrigerants are so harmful to the environment, CFC refrigerants were the first refrigerants to be banned from production. CFC refrigerant production was stopped December 31, 1995. The Environmental Protection Agency (EPA) banned the production, but not use, of CFC refrigerants in 1995. The production ban allows CFC refrigerants left in systems and at reclamation facilities to still be used. Over time, the increasing costs and inconvenience of obtaining CFC refrigerants will discourage most uses. Examples of CFC refrigerants are R-11, R-12, R-13, R-14, R-113, and R-114.

CFC refrigerants are classified as Class I substances. A *Class I substance* is a refrigerant that poses the highest danger to the environment. The EPA has eight groups of Class I - Ozone-Depleting Substances that include groups such as Halons™. **See Figure 3-3.**

ATOFINA Chemicals Co.

CFC refrigerants are sold in cylinders color-coded such as light green for R-22, purple for R-113, orange for R-11, medium blue for R-13, and coral for R-13B.

EPA CLASS I – OZONE-DEPLETING SUBSTANCES									
Chemical Name	Lifetime*	ODP1† (WMO 2002)	ODP2‡ (Montreal Protocol)	ODP3§ (40 CFR)	GWP1† (WMO 2002)	GWP2‖ (SAR)	GWP3# (TAR)	GWP4§ (40 CFR)	CAS Number
Group I									
CFC-11 (CCl_3F) Trichlorofluoromethane	45	1.0	1.0	1.0	4680	3800	4600	4000	75-69-4
CFC-12 (CCl_2F_2) Dichlorodifluoromethane	100	1.0	1.0	1.0	10720	8100	10600	8500	75-71-8
Group II									
Halon 1211 (CF_2ClBr) Bromochlorodifluoromethane	16	6.0	3.0	3.0	1860		1300		353-59-3
Group III									
CFC-112 ($C_2F_2Cl_4$) Tetrachlorodifluoroethane		1.0	1.0	1.0					76-12-0
Group IV									
CFC-10 (CCl_4) Carbon Tetrachloride	26	0.73	1.1	1.1	1380	1400	1800	1400	56-23-5
Group V									
Methal Chloroform ($C_2H_3Cl_3$) 1,1,1-Trichloroethane	5.0	0.12	0.1	0.1	144		140	110	71-55-6
Group VI									
Methyl Bromide (CH_3Br)	0.7	0.38	0.6		5		5		74-83-9
Group VII									
HBFC-12B1 (CHF_2Br)		0.74	0.74						
C_2HFBr_4		0.3-0.8	0.3-0.8						
Group VIII									
Chlorobromomethane (CH2BrCI)	0.37		0.12	0.12					

* in years
† numbers from Scientific Assessment of Ozone Depletion, 2002
‡ numbers from the Montreal Protocol
§ numbers from stratospheric ozone protection regulations-CAA
‖ numbers from Intergovernmental Panel on Climate Change (IPCC)
\# numbers from IPCC Third Assessment Report: Climate Change 2201

Figure 3-3. The EPA has eight groups under the designation Class I – Ozone-Depleting Substances that are considered to present the highest danger to the environment.

Hydrochlorofluorocarbons (HCFCs)

Hydrochlorofluorocarbon (HCFC) refrigerant is a refrigerant that consists of hydrogen, chlorine, fluorine, and carbon. HCFC refrigerants are less harmful to the environment and are a class of chemicals used as an interim replacement for CFC refrigerants. HCFCs contain chlorine and are classified as ozone-depleting chemicals, but to a much lesser extent than CFCs. Because HCFC refrigerants are less harmful than CFC refrigerants, HCFCs will be produced until the year 2030. HCFC molecules are not as stable as CFC molecules and have a much shorter lifespan. The shorter lifespan results in less damage to the ozone layer. Examples of HCFC refrigerants are R-22, R-123, and R-124.

HCFC refrigerants are classified as Class II substances. A *Class II substance* is a refrigerant that is considered to present a medium danger to the environment. The EPA has one group of Class II - Ozone-Depleting Substances. **See Figure 3-4.**

Hydrofluorocarbons (HFCs)

Hydrofluorocarbon (HFC) refrigerant is a refrigerant that consists of hydrogen, fluorine, and carbon. HFCs have no chlorine atoms and create no threat to the ozone layer. However, HFC refrigerants do contribute a small amount to global warming. HFC refrigerants are the long-term replacement for CFC and HCFC refrigerants. The most popular HFC refrigerant is HFC-134a. HFC-134a is a replacement for R-12. Other examples of HFC refrigerants are R-32, R-143a, R-152a, and R-125.

HFC refrigerants are a separate group of refrigerants. HFC substances are considered to present low danger or no danger to the environment. The EPA has one group of HFC refrigerants. **See Figure 3-5.**

HFC REFRIGERANT GROUP

Refrigerant	Molecular Formula	Chemical Name
HFC-23	CHF_3	Trifluoromethane
HFC-32	CH_2F_2	Difluoromethane
HFC-125	CHF_2CF_3	Pentafluoroethane
HFC-134a	CF_3CH_2F	Tetrafluoroethane
HFC-152a	CH_3CHF_2	Difluoroethane

Figure 3-5. HFC refrigerants are considered to present a low danger or no danger to the environment.

Discussion on the phase-out of R-134a have been started by the White House. Refrigerant HFO-123YF is the leading alternative to replace R-134a at this time.

Technical Fact

Because HFCs absorb infrared radiation like a greenhouse gas, HFC acceptability for the future is uncertain. HFC-134a and HFC-152a have global warming potential (GWP) numbers of approximately 1, compared to a GWP of 8.5 for CFC-12. While HFC-134a appears to be the most environmentally friendly alternative for newly manufactured equipment, other refrigerants are more attractive as replacements for CFC-12 in existing systems. The direct replacement of HFC-134a in a system designed for CFC-12 results in about a 10% decrease in the capacity of the refrigeration system. The decrease in system efficiency causes an increase in energy consumption due to the longer run times required to satisfy the cooling load. The increase in power consumption corresponds to an increase in greenhouse gas emissions at the power plant.

EPA CLASS II – OZONE-DEPLETING SUBSTANCES

Chemical Name	Lifetime*	ODP1† (WMO 2002)	ODP2‡ (Montreal Protocol)	ODP3§ (40 CFR)	GWP1† (WMO 2002)	GWP2‖ (SAR)	GWP3# (TAR)	GWP4§ (40 CFR)	CAS Number
HCFC-21 ($CHFCl_2$) Dichlorofluoromethane	1.7	0.04	0.04		143		210		75-43-4
HCFC-22 (CHF_2Cl) Monochlorodifluoromethane	12.0	0.05	0.055	0.05	1780	1500	1700	1700	75-45-6
HCFC-124 (C_2HF_4Cl) Monochlorotetrafluoroethane	5.8	0.02	0.02-0.04	0.02	599	470	620	480	2837-89-0
HCHFC-131 ($C_2H_2FCl_3$) Trichlorofluoromethane		0.007-0.05	0.007-0.05						359-28-4

* in years
† numbers from Scientific Assessment of Ozone Depletion, 2002
‡ numbers from the Montreal Protocol
§ numbers from stratospheric ozone protection regulations-CAA
‖ numbers from Intergovernmental Panel on Climate Change (IPCC)
numbers from IPCC Third Assessment Report: Climate Change 2201

Figure 3-4. The EPA has one group of Class II – Ozone-Depleting Substances that are considered to present a medium danger to the environment.

Perfluorocarbons (PFCs)

Perfluorocarbon (PFC) refrigerant is a refrigerant that consists of carbon and fluorine and that does not deplete stratospheric ozone but has an extremely high global warming potential. PFC refrigerants do not deplete stratospheric ozone. However, PFCs have extremely high global warming potentials (GWPs) and very long lifetimes. The high GWP is what is of concern to the EPA. PFC refrigerants are considered to have low to medium danger to the environment. **See Figure 3-6.**

PFC REFRIGERANTS		
Refrigerant	Molecular Formula	Chemical Name
PFC-14	CF_4	Tetrafluoromethane
PFC-116	CF_3CF_3	Hexafluoroethane
PFC-218	C_3F_8	Octafluoropropane
PFC-318	C_4F_8	Octafluorobutane

Figure 3-6. A PFC refrigerant is considered to present a medium to low danger to the environment but has a high global warming potential.

Cummins Power Generation

Some pump designs have cooling jackets that circulate chilled water from low-pressure chillers that use refrigerants with high boiling points.

HIGH-PRESSURE/LOW-PRESSURE REFRIGERANTS

Refrigerants are also categorized by operating pressure. Refrigerants with low boiling points operate with high pressures. Refrigerants such as R-12, R-22, R-114, R-500, and R-502 are considered to be high-pressure refrigerants. R-13 and R-503 refrigerants are considered to be very high-pressure refrigerants. Refrigerants with high boiling points operate with low pressures. Refrigerants such as R-11 and R-123 are considered low-pressure refrigerants. A low-pressure refrigerant can never replace a high-pressure refrigerant in a system and a high-pressure refrigerant can never replace a low-pressure refrigerant in a system. There is no HFC replacement for R-11 at the present time, but HCFC-123 is considered the interim replacement. **See Figure 3-7.**

REFRIGERANT BOILING POINTS			
Refrigerant	ASHRAE Number	Molecular Weight	Boiling Point*
High-Pressure			
CFC-12	R-12	120.9	-21.6
HCFC-22	R-22	86.5	-41.4
CFC-114	R-114	170.9	38.8
HFC-134a	R-134a	102.0	-15.0
Blend 407C	R-407C	86.2	-46.4
Azeotrope 500	R-500	99.3	-28.3
Azeotrope 502	R-502	111.6	-49.8
Very High-Pressure			
CFC-13	R-13	104.5	-114.6
HFC-23	R-23	70.0	-115.7
Azeotrope 503	R-503	87.5	-126.1
Low-Pressure			
CFC-11	R-11	137.4	74.9
CFC-113	R-113	187.4	117.6
HCFC-123	R-123	152.9	82.2

* in °F

Figure 3-7. A low-pressure refrigerant can never replace a high-pressure refrigerant in a system and a high-pressure refrigerant can never replace a low-pressure refrigerant in a system.

Blends

A *blend* is a mixture of two or more different chemical compounds. A binary blend consists of two different chemical compounds (refrigerants). R-500 refrigerant is a blend of R-12 and R-152a refrigerants. Refrigerant R-502 is a blend of R-22 and R-115 refrigerants. Both R-500 and R-502 are popular binary azeotropic mixtures. A ternary blend consists of three different chemical compounds (refrigerants). R-407C is a refrigerant blend of R-32, R-125, and R-134a refrigerants and is a popular ternary near azeotropic mixture. **See Figure 3-8.**

COMMON REFRIGERANT BLENDS

Refrigerant Blends	ASHRAE Number	Refrigerant
Blend MP39	R-401A	Chlorodifluoromethane (HCFC-22) Difluoroethane (HFC-152a) Chlorotetrafluoroethane (HCFC-124)
Blend HP80	R-402A	Chlorodifluoromethane (HCFC-22) Pentafluorotheane (HFC-125) Propane (R-290)
Blend 407C	R-407C	Difluoromethane (HFC-32) Pentafluoroethane (HFC-125) Tetrafluoroethane (HFC-134a)
Blend 408A	R-408A	Pentafluoroethane (HFC-125) Trifluoroethane (HFC-143a) Chlorodifluoromethane (HCFC-22)
Blend 409A	R-409A	Chlorodifluoromethane (HCFC-22) Chlorotetrafluoroethane (HCFC-124) Chlorodifluoroethane (HCFC-142b)

Figure 3-8. A ternary blend consists of three different chemical refrigerants. For example, R-407C is a refrigerant blend of R-32, R-125, and R-134a refrigerants and is a popular ternary near azeotropic mixture (NARM).

Azeotropic Refrigerant Mixtures

An *azeotropic mixture* is a refrigerant blend that behaves like a new refrigerant made from one chemical. CFC-500 and CFC-502 are azeotropic mixtures that contain R-12 or R-115 (CFC) refrigerants. Because R-500 and R-502 refrigerants contain CFCs, both mixtures are classified as CFC refrigerants. **See Figure 3-9.**

AZEOTROPIC REFRIGERANTS

Refrigerant	Molecular Formula	Composition by Weight-Percentage
CFC-500	CCl_2F_2/CH_3CHF_2	R-12-73.8%/ R-152-26.2%
CFC-502	$CHClF_2/CClF_2CF_3$	R-22-48.8%/ R-115-51.2%
CFC-503	$CHF_3/CClF_3$	R-23-40.1%/ R-13-59.9%
HFC-507A	CHF_2CF_3/CH_3CF_3	R-125-50%/ R-143a-50%
PFC-508A	CHF_3/CF_3CF_3	R-23-39%/ R-116-61%
PFC-508B	CHF_3/CF_3CF_3	R-23-46%/ R-116-54%
PFC-509A	$CHClF_2/CF_3CFCF_3$	R-22-44%/ R-218-56%

Figure 3-9. Because refrigerants R-500 and R-502 contain CFCs, both mixtures are classified as CFC refrigerants.

Azeotropic mixtures are the 500 series of refrigerants, with 500 and 502 being the most popular. Certain azeotropic mixtures are considered near azeotropic refrigerant mixtures (NARMs) and behave differently than the 500 series of refrigerants. Near azeotropic (zeotropic) mixtures have the vapor and liquid concentrations at a given temperature with pressures differing slightly. Measurements indicate that a number of near azeotropic mixtures have low toxicity, are nonflammable, and are more compatible with conventional lubricants.

An azeotropic binary refrigerant mixture creates a third refrigerant with its own individual characteristics. This refrigerant acts like a single component refrigerant over its entire pressure and temperature range.

➤ Technical Fact

Zeotropic Refrigerant Mixtures

Zeotropic mixtures are the 400 series of refrigerants. Refrigerant R-407C is a near azeotropic mixture that contains R-32, R-125, and R-134a HFC refrigerants. Because refrigerant R-407C contains all HFC refrigerants, the mixture is classified as an HFC refrigerant. **See Figure 3-10.**

Zeotropic-blended refrigerants leak from a system in uneven amounts due to the different vapor pressures of the various refrigerants.

▶ Technical Fact

ZEOTROPIC REFRIGERANTS

Refrigerant	Molecular Formula	Composition by Weight-Percentage
HCFC-401A	$CHClF_2/CH_3CHF_2/CHClFCF_3$	R-22-53%/ R-124-34%/ R-152a-13%
HCFC-401B	$CHClF_2/CH_3CHF_2/CHClFCF_3$	R-22-61%/ R-124-28%/ R-152a-11%
HCFC-402A	$CHClF_2/CHF_2CF_3/C_3H_8$	R-22-38%/ R-125-60%/ R-290-2%
HFC-407C	$CH_2F_2/CHF_2CF_3/CF_3CH_2F$	R-32-23%/ R-125-25%/ R-134a-52%
HFC-408A	$CHF_2CF_3CH_3CF_3/CHClF_2$	R-22-47%/ R-125-7%/ R-143a-46%

Figure 3-10. Because refrigerant R-407C contains all HFC refrigerants, the mixture is classified as an HFC refrigerant.

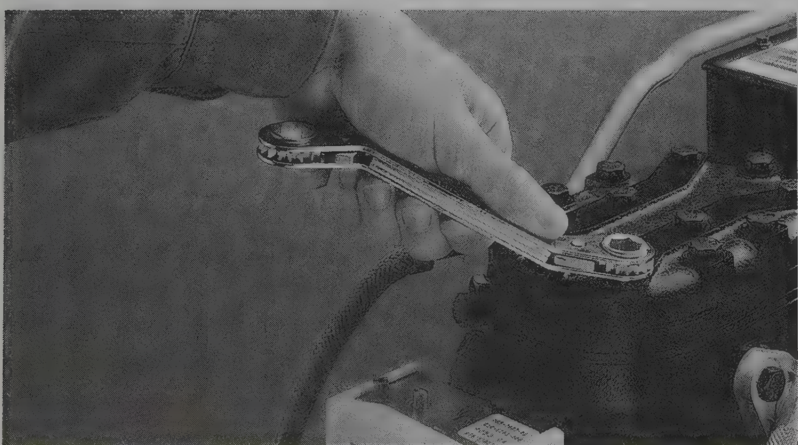
Zeotropic blended refrigerants are charged by weight into the high-pressure side of a system as a liquid.

▶ Technical Fact

A *zeotropic mixture* is a refrigerant blend in which individual refrigerants of the mixture behave independently. These independent characteristics cause a condition called fractionation. *Fractionation* occurs when liquid and vapor are coexisting simultaneously, with one or more refrigerants of a blend leaking at faster rates than other refrigerants of the same blend. Zeotropic refrigerants have a small volumetric composition change and temperature glide as they evaporate and condense. *Temperature glide* is a range of temperatures where refrigerants condense or evaporate for one given pressure. Fractionation and temperature glide are characteristics that can cause difficulty when charging refrigerant vapor into an appliance, when leaks occur, when reading pressure/temperature charts, or when calculating superheat or subcooling.

Substitute Refrigerants

CFC refrigerants have not been manufactured since December 31, 1995. HCFC refrigerants are targeted for production termination in 2030. With the decrease in supply, prices will rise and availability will decrease. Manufacturers are developing replacement or substitute refrigerants for CFC and HCFC refrigerants. **See Figure 3-11.** Replacing CFC-12 with HFC-134a or CFC-11 with HCFC-123 refrigerants requires a refrigerant retrofit. *Refrigerant retrofit* is the changing of refrigerants by following the instructions of the manufacturer for refrigerant replacement. A retrofit procedure includes the changing of components and oil to replace CFC refrigerants with HFC refrigerants.



Yellow Jacket Div., Ritchie Engineering Co., Inc.

A substitute refrigerant used in a system may require that seals and gaskets in the system be replaced.

Zeotropic mixtures should not be used in unmodified equipment. However, performance improvements occur when they are used with modified systems. Systems using zeotropic refrigerant mixtures must be liquid charged.

▶ Technical Fact

REFRIGERANT SUBSTITUTES				
Section 608 Refrigerant	**Application**	**Substitute Refrigerant Product Manufacturers**	**Type**	**Comments**
Air Conditioning				
R-11	Low-pressure centrifugal chillers	DuPont—Suva 123 Honeywell—Genetron 123 Atofina—Forane 123	HCFC Pure Fluid	
Low and Medium Temperature (Interim)				
R-502	Ice Machines and open drives	DuPont—Suva R-402A Honeywell—Genetron R-402A	HCFC/HFC Blend	Higher discharge temperature and average evaporator temperature above -20°F
Medium Temperature (Interim)				
R-12	High-capacity temperature below 15°F evaporator	DuPont—Suva R-401A Honeywell—Genetron R-401A	HCFC/HFC Blend	No oil change above 20°F evaporator temperature unless long piping exist
Medium Temperature (Long Term)				
R-134a	New equipment	DuPont—Suva 134a Honeywell—Genetron 134a Atofina—Forane 134a	HFC Pure Fluid	Performs well with 20°F evaporator temperature or higher

Figure 3-11. Manufacturers are developing replacement or substitute refrigerants for CFC and HCFC refrigerants.

There are no drop-in substitute refrigerants. Substitute refrigerants require a system retrofit.

▶ Technical Fact

REFRIGERANT OILS

Refrigerant oil is oil used to lubricate the compressor bearings of a refrigeration system. Some oil circulates throughout the refrigeration system with the refrigerant. Because oil mixes with the refrigerant as it travels through the system, the oil must be compatible with the refrigerant. **See Figure 3-12.** Oil that is not compatible with the refrigerant will cause poor heat transfer, sludge pockets, and refrigerant breakdown. *Alkylbenzene* is a synthetic lubricant made from propylene and benzene that is used with HCFC-based refrigerants and refrigerant blends. *Glycol* is a refrigerant lubricant used with HFC-based refrigerants. Glycol lubricants are hygroscopic (meaning they absorb water) and cannot be retrofitted. An ester lubricant is a second generation refrigerant lubricant widely used with HFC-based refrigerants. Ester lubricants cannot be mixed with any other refrigerant lubricant.

Yellow Jacket Div., Ritchie Engineering Co., Inc.

Alkybenzene, glycol, polyol ester and mineral oil lubricants must be compatible with the refrigerant in a system.

Refrigerant Oil Properties

The air conditioning and refrigeration industry is changing CFC refrigerants to HCFC refrigerants and eventually to all HFC and PFC refrigerants in compliance with the Clean Air Act. The oils used with refrigerants must

be tested to determine which oil works best with a particular refrigerant and application. Using the proper refrigerant oil ensures that adequate oil returns to the compressor for lubrication. The basic properties of oils that are tested are viscosity, flash point, fire point, and pour point. **See Figure 3-13.**

Refrigerants migrate to the crankcase of a compressor due to the density difference between refrigerants and oils.

Technical Fact

REFRIGERANT OILS	
ASHRAE Refrigerant	Oil*
R-23	Polyol Ester
R-123	Alkylbenzene or Mineral Oil
R-124	Alkylbenzene
R-134a	Polyol Ester
R-401A	Alkylbenzene, Mineral Oil, or Polyol Ester
R-401B	Alkylbenzene, Mineral Oil, or Polyol Ester
R-402A	Alkylbenzene or Polyol Ester
R-402B	Alkylbenzene or Polyol Ester
R-404A	Polyol Ester
R-407C	Polyol Ester
R-407D	Polyol Ester
R-408A	Alkylbenzene or Polyol Ester
R-409A	Alkylbenzene, Mineral Oil, or Polyol Ester
R-410A	Polyol Ester
R-414A	Alkylbenzene, Mineral Oil, or Polyol Ester
R-414B	Alkylbenzene, Mineral Oil, or Polyol Ester
R-416A	Polyol Ester
R-507a	Polyol Ester
R-508A	Polyol Ester
R-508B	Polyol Ester

* Check with compressor manufacturer for recommended lubricant

Figure 3-12. Because the lubricating oil of a system mixes with the refrigerant as it travels through the system, the oil must be compatible with the refrigerant.

Viscosity. *Viscosity* is the measurement of a fluid's internal resistance to flow. Saybolt Universal Seconds is the test used to measure the viscosity of a fluid to determine the thickness or thinness (viscosity) of a fluid.

Flash Point. *Flash point* is the temperature at which a fluid's vapor will ignite without the fluid igniting. Cleveland Cup is the test used to measure the flash point temperature of a fluid.

Fire Point. *Fire point* is the temperature (higher than flash point) at which a fluid will burn for at least 5 seconds. Cleveland Cup is the test used to measure the fire point temperature of a fluid.

Pour Point. *Pour point* is the lowest temperature a fluid can be at and still flow. Arctic Cup is the test used to measure the pour point temperature of a fluid.

The lubrication and antifoaming abilities of oils determine how well oils reduce friction, resulting in less mechanical wear and tear. Properly lubricated equipment results in equipment that is less noisy and operates at lower temperatures.

Waste Refrigerant Oil

Refrigerant oils contaminated with CFCs from a system are not considered hazardous if the refrigerant was not mixed with other waste, refrigerants, or oil from other sources. If oil is destined to be burned, it is subject to EPA specification limits. The EPA must be contacted for proper handling and disposal methods of contaminated oils and refrigerants. **See Figure 3-14.**

Mineral oil is used to lubricate air conditioning and refrigeration systems with CFC refrigerants. Mineral oil is compatible with some HCFC refrigerant systems, but is not compatible with any HFC refrigerant systems.

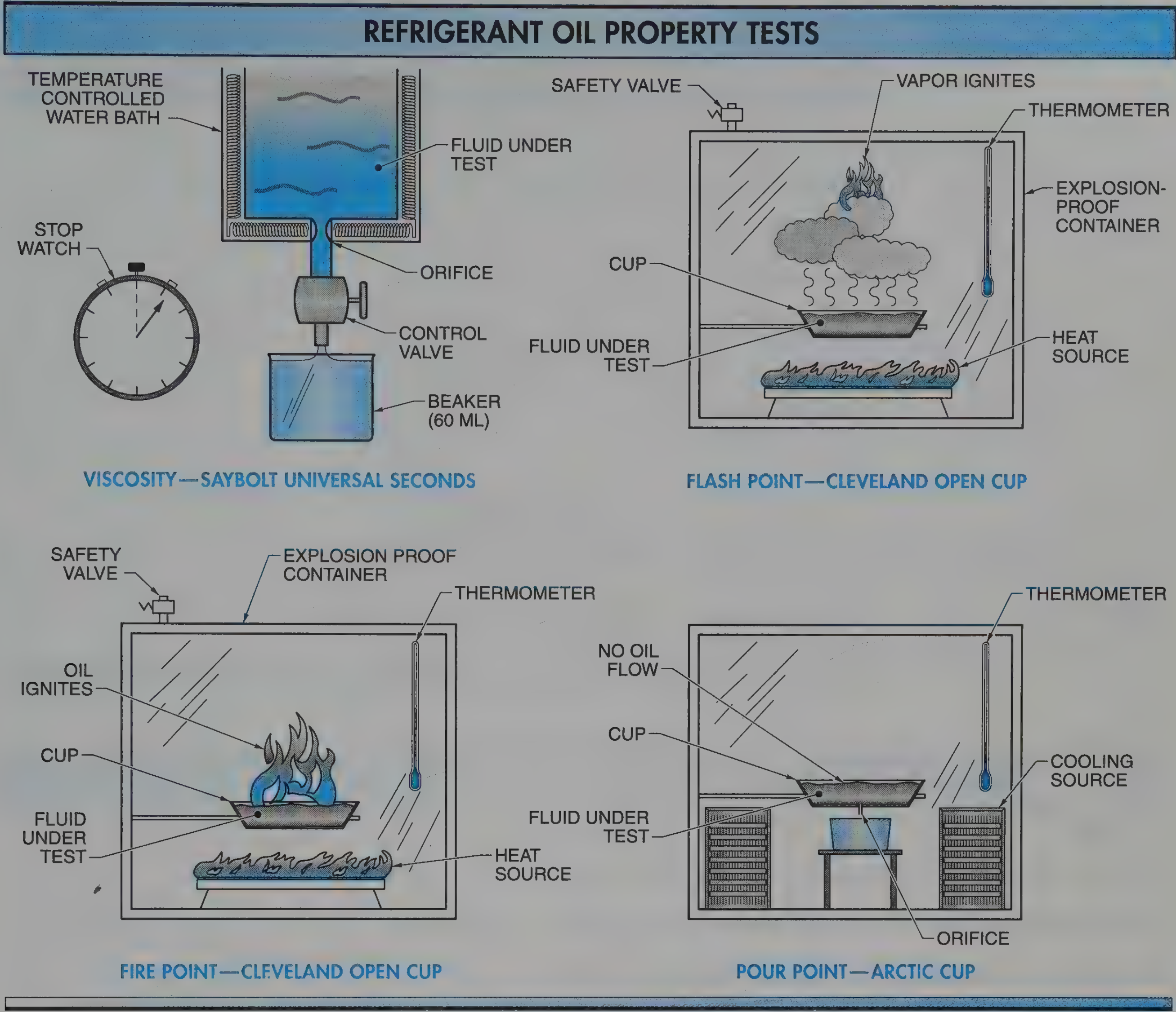


Figure 3-13. Refrigerant oils are tested for viscosity, flash point, fire point, and pour point.

Because of the incompatibility of mineral oils with HCFC and HFC refrigerants, synthetic oils such as alkylbenzene, glycols, and esters are used. Alkylbenzene oils are used with systems that have HCFC refrigerants. Glycols and esters are used with systems that have HFC refrigerants. Compressor manufacturers recommend that a blend of oils be used for some blended refrigerant systems.

A problem with blended refrigerants is oil starvation of the compressor. Oil starvation occurs when a refrigerant fractionates (separates). The refrigerant and oil flow at disproportionate rates, allowing the oil to separate from the refrigerant blend. Refrigerant continues flowing through the system, but the oil builds up in sections of the system, starving the compressor.

Refrigerant oils do not work with the common desiccants of filter/dryers in a system. When oil is incompatible with the desiccant material of a dryer, the oil can be absorbed into the desiccant, reducing the dryer's ability to absorb water and causing a shortage of oil in the system.

STANDARD CONTAMINATED REFRIGERANT SAMPLES											
	R-11	R-12	R-13	R-22	R-113	R-114	R-123	R-134a	R-500	R-502	R-503
Moisture Content: Ppm by weight of pure refrigerant	100	80	30	200	100	85	200	200	200	200	30
Particulate Content: Ppm by weight of pure refrigerant*	80	80	NA	80	80	80	80	80	80	80	NA
Acid Content: Ppm by weight of pure refrigerant†	500	100	NA	500	400	200	500	100	100	100	NA
Mineral Oil Content: % by weight of pure refrigerant	20	5	NA	5	20	20	20	5	5	5	NA
Viscosity	300	150		300	300	300	300	150‡	150	150	
Noncondensable Gases (Air): % by volume	NA	3	3	3	NA	3	NA	3	3	3	3

* particulate content consists of inert material and complies with particulate requirements
† acid consists of 60% oleic acid and 40% hydrochloric acid on a total number basis
‡ synthetic ester-based oil

Figure 3-14. The EPA must be contacted for proper handling and disposal methods for contaminated oils and refrigerants.

Discussion Questions

1. When were the first fluorocarbon refrigerants developed?
2. What causes refrigerants to change state?
3. Why were CFC refrigerants thought of as miracle substances?
4. Why were CFC refrigerants banned?
5. Why are PFC refrigerants of concern to the EPA?
6. How are refrigerants with high boiling points used?
7. Why is R-407C a ternary blend refrigerant?
8. Why do zeotropic refrigerants fractionate?
9. What is the primary function of a refrigerant oil?
10. Why are synthetic oils used in air conditioning and refrigeration systems manufactured today?

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REVIEW QUESTIONS

Name ______________________ Date ____________

D 1. A refrigerant absorbing heat changes state from a ___ to a ___.
- A. liquid; solid
- B. solid; vapor
- C. vapor; liquid
- D. liquid; vapor

B 2. Refrigerants made with fluorine are known as ___ refrigerants.
- A. hydrocarbon
- B. fluorocarbon
- C. halogen
- D. chlorofluorocarbon

D 3. ___ is a number given to refrigerants to represent the relative ozone depletion potential of a refrigerant.
- A. CFC
- B. HCFC
- C. GWP
- D. ODP

A 4. ___ refrigerants are considered to be most harmful to the environment.
- A. CFC
- B. HFCF
- C. HFC
- D. HCFC

A 5. CFC-11 refrigerants, CFC-12 refrigerants, and Halons™ are Class ___ -ozone-depleting substances.
- A. I
- B. II
- C. III
- D. IV

C 6. ___ refrigerants are the interim refrigerant replacements for CFC refrigerants.
- A. PFC
- B. HFC
- C. HCFC
- D. Halon™

B 7. ___ refrigerants have no chlorine atoms.
- A. CFC
- B. HFC
- C. HCFC
- D. PFC

C 8. When HFC-134a is used as a direct replacement in a system designed for CFC-12, typically there is a ___% decrease in the capacity of the refrigeration system.

A. 2
B. 5
C. 10
D. 25

C 9. ___ refrigerants have extremely high GWP numbers.

A. CFC
B. HFC
C. PFC
D. HCFC

D 10. Refrigerants with low boiling points operate with ___ pressure(s).

A. no
B. low
C. medium
D. high

A 11. A(n) ___ is a refrigerant blend that behaves like a single new refrigerant.

A. azeotropic mixture
B. zeotropic mixture
C. ternary blend
D. binary blend

B 12. ___ is a range of temperatures where refrigerants condense or evaporate for one given pressure.

A. Fractionation
B. Temperature glide
C. Superheating
D. Subcooling

B 13. The second generation of lubricants designed for HFC refrigerants are the ___ lubricants.

A. glycol
B. ester
C. alkylbenzene
D. hygroscopic

B 14. ___ is the temperature at which a fluid's vapor will ignite without the fluid igniting.

A. Viscosity
B. Flash point
C. Fire point
D. Pour point

D 15. When blended refrigerants ___, the oil builds up in sections of the system.

A. dissolve
B. mix
C. combine
D. fractionate

4

Ozone Depletion

Ozone is constantly being produced and destroyed in an ongoing natural cycle. In the past, the overall amount of ozone was essentially stable because the production and destruction were balanced. In the 1970s, scientists became concerned that certain chemicals were damaging the ozone layer that protects the earth from ultraviolet radiation. In the early 1980s, the discovery that the ozone layer was thinning in the southern hemisphere over Antarctica justified the concern of scientists. While the ozone layer did not completely disappear from the Antarctic area, the ozone layer had become so thin that scientists referred to the area as a "hole in the ozone layer."

THE ATMOSPHERE

The atmosphere that surrounds the Earth has three main layers or regions. The region that covers the surface of the Earth to about 6 or 7 miles up is called the troposphere. The troposphere is where oxygen (O_2) is located for humans and animals to breathe. The region above the troposphere is the stratosphere. The stratosphere is approximately 8 miles to 30 miles above the surface of the Earth. The ozone (O_3) layer is located in the stratosphere at approximately 28 miles above the Earth's surface. The ozone layer plays the vital role of absorbing harmful ultraviolet (UV) radiation from the sun. The region above the stratosphere is the ionosphere. The ionosphere is approximately 31 miles to 300 miles above the surface of the Earth. **See Figure 4-1.**

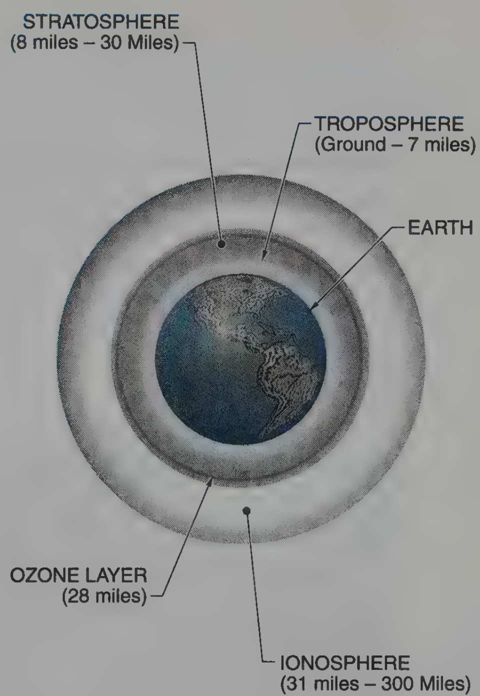


Figure 4-1. The atmosphere that surrounds the Earth has three main layers or regions: the troposphere, stratosphere, and ionosphere.

OZONE DEPLETION

Ozone is a gas that occurs at ground level and in the upper levels of the stratosphere. Ozone is undesirable when it exists at ground level, where

ozone is harmful to breathe and is the prime ingredient in smog. However, ozone present in the stratosphere is beneficial because it protects the planet from UV radiation. The ozone layer acts as a blanket that protects the Earth from harmful UV radiation by keeping the radiation from reaching the planet's surface. Ozone in the stratosphere is constantly being produced and destroyed in a natural cycle. Large increases of chlorine and bromine in the stratosphere are known to upset the natural balance of the ozone layer.

CFC and HCFC gases are mixed throughout the atmosphere by large-scale winds and survive the several-year journey up to the stratosphere where CFCs are eventually broken down by ultraviolet radiation. The substances produced by breaking down the CFC molecules deplete the ozone layer. The decreased amount of ozone may let an increased amount of UV radiation penetrate the stratosphere and troposphere and reach the surface of the planet. **See Figure 4-2.** Also, oxygen present in the stratosphere decreases the amount of UV radiation that the ozone layer is able to absorb.

To help protect the American public from overexposure to UV radiation, the EPA maintains several education and outreach projects. Chief among these is the UV index, a number that provides the next day's forecast of UV levels for 58 cities across the United States.

Technical Fact

Ozone Destruction

Ozone is destroyed when ultraviolet radiation attacks a CFC molecule and breaks away chlorine atoms from the CFC molecule. The free chlorine atoms destroy ozone molecules (O_3). Oxygen (O_2) and chlorine monoxide molecules are formed in the stratosphere when chlorine atoms break down ozone molecules. The chlorine monoxide molecule is so unstable that the chlorine and oxygen atoms separate, allowing the chlorine atom to be free to attack other ozone molecules and continuing the cycle. **See Figure 4-3.** Chlorine atoms or other ozone-depleting substances (ODSs) destroy ozone molecules, but not the individual atoms of the molecule. It is estimated that one chlorine atom can destroy over 100,000 ozone molecules before finally being removed from the stratosphere.

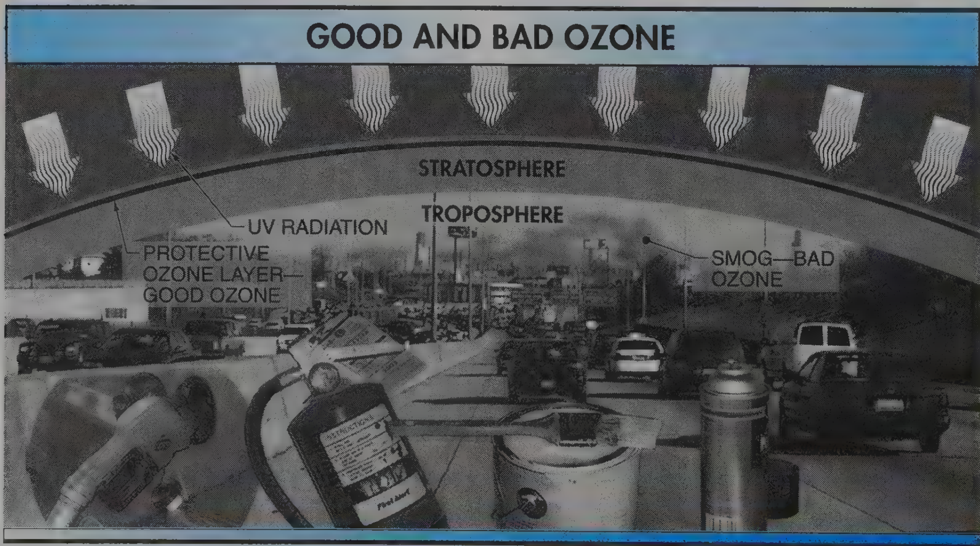


Figure 4-2. CFC molecules deplete the ozone layer, which may let an excess amount of UV radiation penetrate the stratosphere and troposphere and reach the surface of the planet.

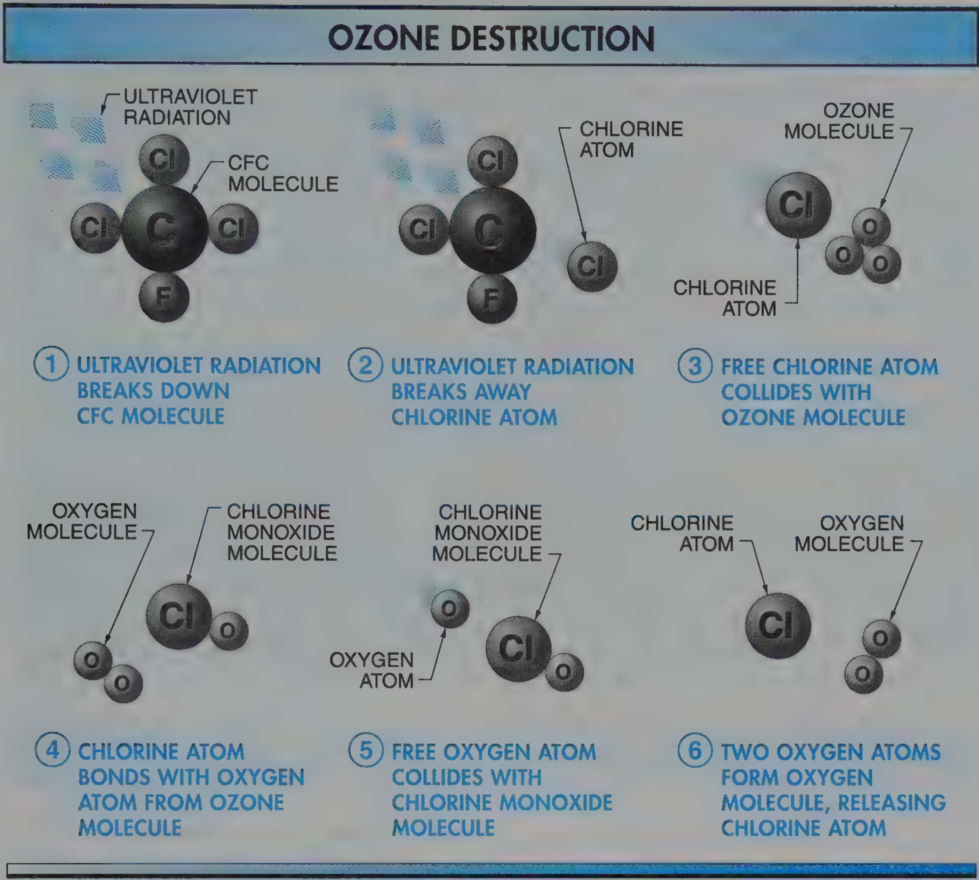


Figure 4-3. Chlorine monoxide molecules are so unstable that the chlorine and oxygen atoms separate, allowing the chlorine atom to be free again to destroy 100,000 other ozone molecules.

An ozone molecule consists of three oxygen atoms.

Technical Fact

Ultraviolet Radiation

Ultraviolet radiation is the portion of the light spectrum that is damaging to living organisms. **See Figure 4-4.** CFCs release chlorine atoms when attacked by UV radiation and begin the cycle that results in ozone depletion. The greater the ozone depletion, the greater the amount of UV radiation reaching the surface of the planet. Scientists believe that a one percent reduction in the ozone layer results in a two percent increase in the amount of UV radiation reaching the surface of the planet. Although some UV radiation reaches the surface of the planet even without ozone depletion, the harmful effects of UV radiation increase as a result of ozone depletion.

Ultraviolet radiation has been linked to skin cancer, cataracts, damage to materials like plastics, and harm to crops and marine organisms.

Scientists have measured the chlorine in the stratosphere. 3% is from volcanos, 15% is from methyl chloride, and 82% is from ODS. 51% of the ODS is from CFC-11 and CFC-12.

Technical Fact

Evidence of Ozone Depletion

In the early 1970s, researchers began to investigate the effects of various chemicals on the ozone layer, particularly CFCs, which contain chlorine. Researchers also examined the potential impacts of other chlorine sources. The results demonstrated that chlorine molecules from swimming pools, industrial plants, sea salts, and volcanoes do not reach the stratosphere in any significant amounts. Chlorine compounds from these sources readily combine with water, and repeated

atmospheric measurements show that natural chlorine compounds very quickly rain out of the troposphere and fall to Earth. In contrast, CFCs are very stable and do not rain out of the atmosphere. CFCs are so stable that only exposure to strong UV radiation can cause CFC molecules to break down.

Scientists have concluded that not only is there ozone depletion, but that CFCs are doing the damage. Volcanic eruptions are powerful events and are capable of injecting hydrogen chloride (HCl) high into the atmosphere; but the vast majority of volcanic eruptions are too weak to eject material as high as the stratosphere. **See Figure 4-5.**

Similarly, oceans send large volumes of sea salt containing chlorine into the atmosphere on a daily basis. Sea salt from oceans is released by rain very low in the atmosphere. By being released very low in the atmosphere (in the troposphere), sea salt, and thus chlorine, never reaches the stratosphere. Rain effectively scrubs the lower atmosphere clean, removing the natural forms of chlorine. Both sea salt and HCl are extremely soluble in water, as opposed to CFCs, which do not dissolve in water. If natural compounds such as sea salt and HCl accumulated in large quantities in the stratosphere, the compounds would produce ozone depletion.

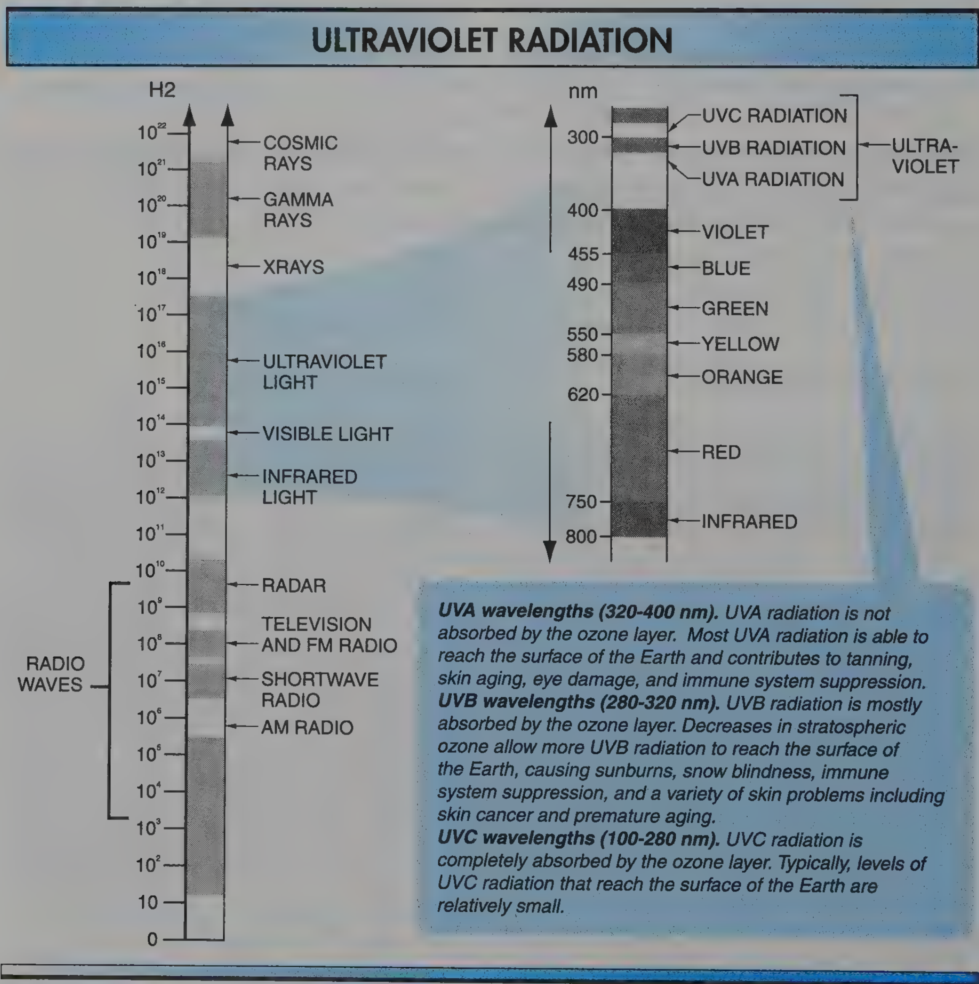


Figure 4-4. Ultraviolet radiation is beyond the visible light spectrum seen by humans and is composed of three bands.

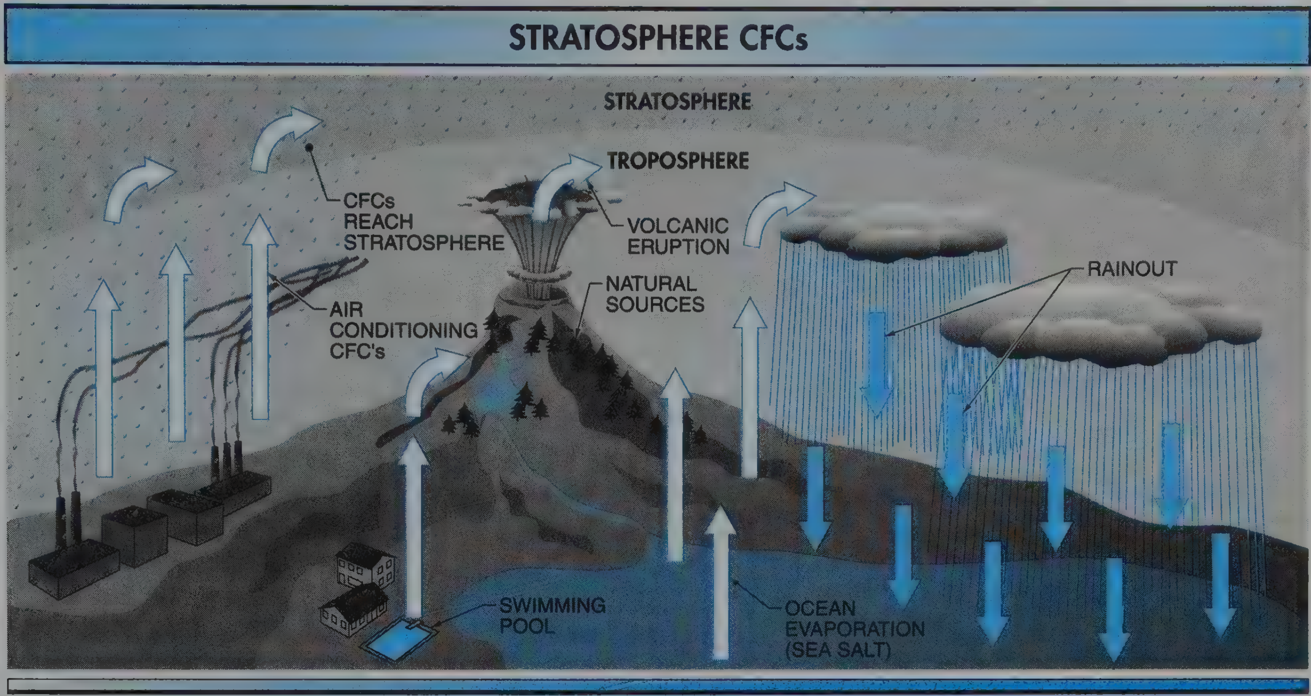


Figure 4-5. CFCs are very stable and do not rain out of the atmosphere like natural chlorine.

Measurements show that concentrations of natural chlorine vanish very rapidly as altitude increases. Neither sea salt from ocean evaporation or tropospheric-level volcanic eruptions (such as Mt. Erebus in Antarctica) contribute significantly to stratospheric chlorine levels. The historical record shows no significant increase in stratospheric chlorine levels following even the most major volcanic eruptions. The dramatic increase in chlorine concentrations simply cannot be explained by a concurrent increase in volcanic activity.

It is the stability of CFC molecules that allows the threat to the ozone layer to occur. Chlorine monoxide found in the upper stratosphere is another indication that the ozone layer is being destroyed. The strongest evidence that CFCs are in the stratosphere is a measurement of CFCs in air samples from the stratosphere. **See Figure 4-6.** It is presently accepted that CFCs and other substances such as Halon™ used in human activities are the primary sources of chlorine atoms in the stratosphere.

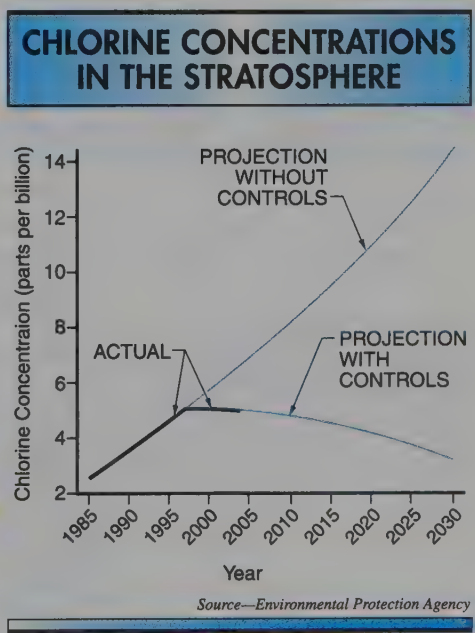


Figure 4-6. The strongest evidence that CFCs are in the stratosphere is a measurement of CFCs in air samples from the stratosphere.

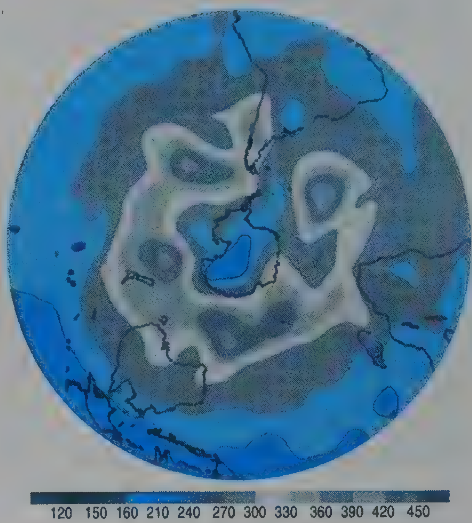
Effects of Stratospheric Ozone Depletion and Ground-Level Ozone Accumulation

There are human and environmental effects of ozone depletion. Ozone depletion contributes to or can cause skin cancer (which is now one of the fastest growing forms of cancer), cataracts, and damage to the human immune system. Ozone depletion affects marine and plant life by reducing growth. Ozone depletion also leads to a reduction in agricultural crops and commercial forest yields, reduced growth and survivability of tree seedlings, and an increased susceptibility to diseases and pests. At present, ozone depletion is limited to certain regions, but is considered a global problem.

The depletion of the ozone layer reduces crop yields and marine life, and increases ground-level ozone.

▶ Technical Fact

The effects of ground-level (bad) ozone accumulation are typically experienced in hot weather. According to the EPA, millions of people live in areas where ozone health standards are not met. **See Figure 4-7.** Low-level ozone also damages vegetation and ecosystems.



The ozone hole (ozone thinning of 70%) is a large-scale destruction of the ozone layer over Antarctica.

EFFECTS OF LOW-LEVEL OZONE

Ozone Level	Color	Air Quality Index Value	Health Effects and Protective Actions
Good	Green	0 to 50	No health effects are expected
Moderate	Yellow	51 to 100	Unusually sensitive people may experience respiratory effects from prolonged exposure during outdoor exertion *Limit prolonged outdoor exertion
Unhealthy for sensitive groups	Orange	101 to 150	Sensitive people may experience respiratory symptoms and reduced lung functions *Limit time and amount of outdoor exertion *Plan outdoor activities by checking predicted state agency ozone levels
Unhealthy	Red	151 to 201	Anyone can experience respiratory effects (cough or deep pain) *Children should limit outdoor exertion *Plan outdoor activities by checking predicted state agency ozone levels
Very Unhealthy	Violet	201 to 300	Everyone will experience moderate to severe lung function reduction and some will experience severe respiratory effects with moderate exertion People with asthma or or other respiratory conditions will be severely affected, leading to increased medication usage and need for medical attention *Sensitive people must avoid outdoors, others and children should limit outdoor exertion and avoid moderate to heavy exertion
Hazardous	Maroon	301 to 500	*Everyone must avoid any outdoor exertion

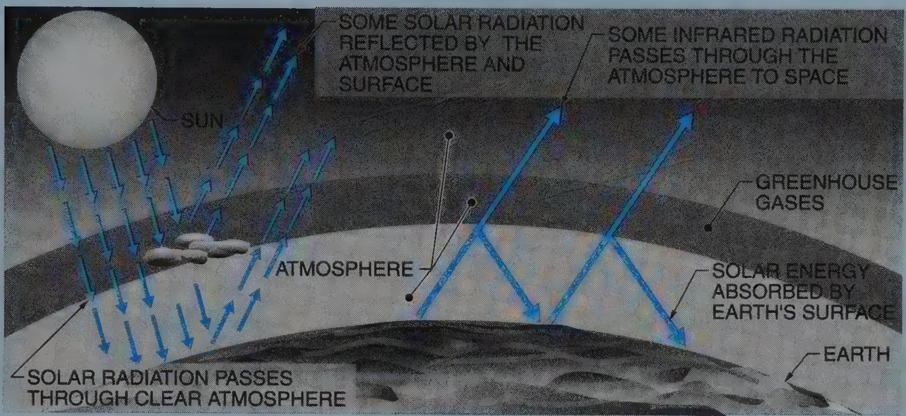
Figure 4-7. According to the EPA, millions of people live in areas where health standards for ozone exposure are not met.

GLOBAL WARMING

Energy from the sun drives the weather and climate of the Earth and heats the Earth's surface. The Earth radiates some of the sun's energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat like the panels of a greenhouse. Without the natural greenhouse effect, temperatures would be much lower than they are, and life today would not be possible. With natural greenhouse gases, the average temperature of the Earth is 54°F.

Since the beginning of the Industrial Revolution, atmospheric concentrations of carbon dioxide have increased 141%, methane concentrations have increased 260%, and nitrous oxide concentrations have increased 120%.

Global mean temperatures have increased 0.5°F to 1.12°F since the late 19th century. The past century's 10 warmest years all occurred between 1998 and 2014. The warmest year ever was 2010.



Source—Environmental Protection Agency

GLOBAL WARMING

Besides ozone depletion, there is another associated problem called global warming. Global warming is also known as the greenhouse effect. Global warming occurs when heat is trapped in the troposphere. The higher temperatures can have consequences such as drought, disease, floods, and lost ecosystems.

Global warming and ozone depletion are both caused by man-made chemicals. Greenhouse gases such as CFCs contribute to global warming. CFCs have high ozone-depleting potential (ODP) numbers and high global warming potential (GWP) numbers. HCFCs have low ODP numbers, HFCs have zero ODP numbers, and both have low GWP numbers compared to CFCs. **See Figure 4-8.**

OZONE DEPLETION AND GLOBAL WARMING POTENTIALS

Refrigerant	Lifetime*	ODP†	GWP‡
CFC-11	45	1.0	4
CFC-12	100	1.0	8.5
CFC-113	85	0.8	5
CFC-114	300	1.0	9.3
CFC-115	1700	0.6	9.3
HCFC-22	11.8	0.055	1.7
HCFC-123	1.4	0.02	0.09
HCFC-124	6	0.022	.48
HCFC-141b	9.2	0.1	.63
HCFC-142b	18.5	0.065	2
HFC-32	5	0	0.55
HFC-125	29	0	3.4
HFC-134a	13.8	0	1.3
HFC-143a	52	0	4.3
HFC-152a	1.4	0	0.12
HFC-236fa	220	0	9.4

* in years
† Ozone Depletion Potential (ODP)
‡ Global Warming Potential (GWP)

Figure 4-8. CFCs have high ozone depletion potential (ODP) numbers with high global warming potential (GWP) numbers compared to most HCFC and HFC refrigerants.

The ozone-depleting potential (ODP) is the measurement of the ability of CFC and HCFC refrigerants to destroy ozone. CFC (R-11 and R-12) refrigerants have the highest ODP while HFC (R-134a) refrigerants have the lowest ODP.

Technical Fact

Discussion Questions

1. What are the three main regions of the atmosphere?
2. How is the surface of the Earth protected from UV radiation?
3. How do chlorine atoms destroy ozone molecules?
4. How does stratospheric ozone depletion affect surface UV radiation?
5. Why do scientists believe that CFCs are depleting the ozone layer?
6. How do natural and man-made chlorine rise through the atmosphere?
7. How do high-level ozone depletion and low-level ozone accumulation affect humans?
8. How do CFCs affect global warming?

Digital Resources

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Access Code: 827160

REVIEW QUESTIONS

Name ____________________ Date ____________

A 1. The ___ is the layer of the atmosphere approximately 8 miles to 30 miles above the surface of the Earth.
   A. stratosphere
   B. ionosphere
   C. mesosphere
   D. troposphere

A 2. The ozone layer is part of the ___.
   A. stratosphere
   B. ionosphere
   C. mesosphere
   D. troposphere

C 3. The ozone layer protects the planet surface from ___.
   A. losing oxygen
   B. ozone molecules
   C. UV radiation
   D. chlorine atoms

D 4. CFCs take ___ to journey up to the ozone layer.
   A. 1 month
   B. several months
   C. 1 year
   D. several years

C 5. To help the American public, the EPA provides a daily forecast of the next day's ___ number.
   A. GWP
   B. chlorine monoxide
   C. UV index
   D. oxygen

A 6. CFC molecules are destroyed by ___.
   A. UV radiation
   B. chlorine atoms
   C. oxygen atoms
   D. ozone molecules

B 7. Ozone molecules are destroyed by ___.
   A. UV radiation
   B. chlorine atoms
   C. oxygen atoms
   D. CFC molecules

B 8. Scientists believe that a 1% reduction in the ozone layer results in a ___ % increase in UV radiation reaching the surface of the planet.

A. 1
B. 2
C. 4
D. 10

D 9. ___ from swimming pools and sea salts rains out of the troposphere and does not reach the stratosphere.

A. Radiation
B. Carbon Monoxide
C. Oxygen
D. Chlorine

C 10. ___ found in the upper atmosphere indicates that ozone molecules are being destroyed.

A. Oxygen
B. UV radiation
C. Chlorine monoxide
D. Smog

B 11. CFCs and substances such as ___ are the primary source of chlorine molecules in the stratosphere.

A. HFCs
B. Halons™
C. carbon monoxide
D. HCFCs

A 12. The effects of ground-level (bad) ozone accumulation are typically experienced in ___ weather.

A. hot
B. warm
C. cool
D. cold

A 13. The primary effect of ground-level ozone accumulation is ___.

A. respiratory symptoms
B. skin cancer
C. cataracts
D. reduced growth

D 14. Global warming is also known as ___.

A. ODP
B. CFC
C. ozone depletion
D. the greenhouse effect

B 15. Global warming occurs when heat is trapped in the ___.

A. ozone layer
B. troposphere
C. stratosphere
D. ionosphere

5 Regulatory Requirements

In the 1970s, scientists named M. J. Molina and F. S. Rowland presented the case that CFCs and bromine are responsible for ozone depletion. Because of the theory of Molina and Rowland, plus public concern, a series of international meetings were held in the 1980s to address the concerns of ozone depletion; these meetings produced a report known as the Montreal Protocol. In the 1990s, the United States' Clean Air Act was amended to institute a national policy to control substances that deplete the ozone layer and cause global warming.

MONTREAL PROTOCOL

On September 16, 1987, the United States and 22 other countries signed the Montreal Protocol on substances that deplete the ozone layer. The Montreal Protocol is an international environmental agreement that establishes requirements to phase out ozone-depleting CFC substances worldwide. **See Figure 5-1.** Many members of the international community responded to the discovery of the hole in the ozone layer over Antarctica by signing the Montreal Protocol agreement to reduce the production of ozone-depleting substances. The requirements of the Montreal agreement were later modified, leading to the phaseout of CFC refrigerant production in 1996 in all developed nations. In addition, a 1992 amendment to the Montreal Protocol established a schedule for the phaseout of HCFC refrigerants. By May 14, 1993, more than 90 nations, representing approximately 95% of the companies in the world that produce CFCs and Halons™, had signed the Montreal Protocol. The Montreal Protocol as amended is implemented in the U.S. through Title VI of the Clean Air Act, which is enforced by the Environmental Protection Agency (EPA). As of June 2003, 168 nations had signed the Montreal Protocol.

Excise Tax

As part of the Omnibus Budget Reconciliation Act of 1989, the U.S. Congress levied an excise tax on the sale of CFCs and other chemicals that deplete the ozone layer, with specific exemptions for exports and recycling. The original excise tax was amended in 1991 with a tax increase.

The Montreal Protocol is a treaty among nations that controls the production of chlorofluorocarbon and hydrochlorofluorocarbon refrigerants.

▸ Technical Fact

MONTREAL PROTOCOL—INTERNATIONAL ENVIRONMENTAL AGREEMENT

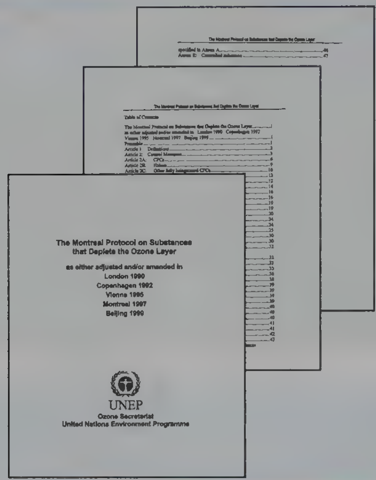
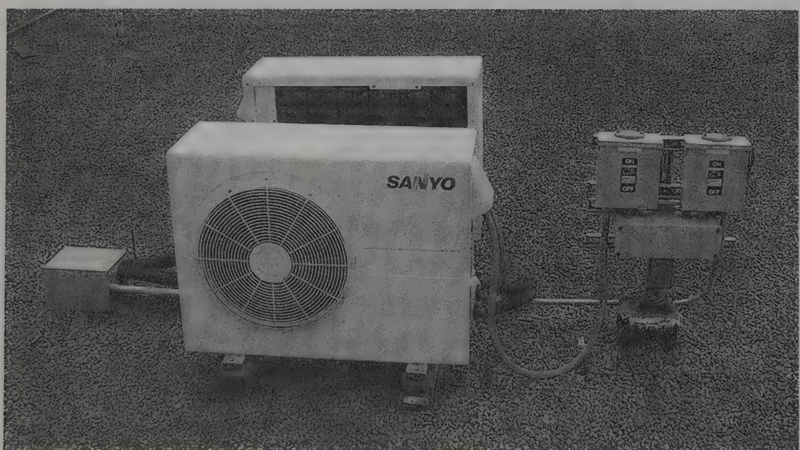


Figure 5-1. The Montreal Protocol is an international environmental agreement that establishes requirements for phasing out ozone-depleting CFCs worldwide.

Advance Notice of Proposed Rulemaking (ANPRM)

On May 1, 1990, the EPA published an advance notice of proposed rulemaking (ANPRM, 55 FR 18256) that addresses issues related to the development of a national CFC recycling program. The ANPRM notice emphasized the importance of recycling CFC refrigerants and allowed the continued use of equipment requiring CFC refrigerants. **See Figure 5-2.**



The EPA 1990 ANPRM notice and the Montreal Protocol—Copenhagen revisions of 1992 emphasized the importance of recycling CFC refrigerants for continued use in air conditioning equipment.

United Nations Development Programme (UNDP) Montreal Protocol Unit (MPU) works with public and private partners in countries to meet the targets of the Montreal Protocol.

▶ Technical Fact

London Amendments to the Protocol

At the second membership meeting of the Montreal Protocol parties, held in London on June 29, 1990, the parties to the Protocol passed amendments and adjustments which called for a full phaseout of already regulated CFC refrigerants and Halons™ by the year 1996. The parties also voted to phase out HCFCs by the year 2020, but with the possibility of allowing use until the year 2040.

Copenhagen Revisions to the Montreal Protocol

On November 25, 1992, the fourth meeting of the Montreal Protocol parties was convened in Copenhagen. The attending parties took a number of actions, including acceleration of the phaseout of CFC refrigerants and Halons™. HCFC refrigerants were also added to the list of chemicals to be controlled under the Montreal Protocol. The new schedule stopped the production of Halons™ after 1993 and CFCs after 1995. HCFC refrigerants can be produced until 2030. Talks may accelerate the schedule to the year 2020.

The Montreal Protocol is a global policy and the Clean Air Act (CAA) is a federal law of the United States. Some state and local governments may establish laws that follow the Clean Air Act/EPA regulations or establish laws with stricter regulations. Title VI– *Stratospheric Ozone Protection* of the Clean Air Act includes requirements for recycling, disposal, and emissions reduction for Class I (CFCs and Halons™) and Class II (HCFCs) substances. **See Figure 5-3.**

ANPRM, 55 FR 18256

Vol. 57 No. 238 Thursday, December 10, 1992 p 58644 (Proposed Rule 1/6187
ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 82

[FRL-4542-9]

Protection of Stratospheric Ozone; Refrigerant Recycling

AGENCY: Environmental Protection Agency.

ACTION: Proposed Rule.

SUMMARY: In this document, EPA proposes regulations under section 608 of the Clean Air Act (the Act) that would establish a recycling program for ozone depleting refrigerants recovered during the servicing and disposal of air conditioning or refrigeration equipment. The proposed regulations would require persons servicing air conditioning and refrigeration equipment to observe certain service practices that reduce refrigerant emissions and would establish equipment and off-site reclaimer certification programs. In addition, EPA would require that ozone depleting compounds contained "in bulk" in appliances be removed prior to disposal of the appliances, and that all air conditioning and refrigeration equipment, except for small appliances and room air conditioners, be provided with a servicing aperture that would facilitate recovery of the refrigerant. These proposed re... significantly reduce emissions of ozone deplet... and therefore aid U.S. and global efforts to m... to the ozone layer.

DATES: Written comments on the proposed rule m... on or before January 22, 1993. A public hearin... for December 23, 1992 in the EPA Auditorium, 1... M St., SW., Washington, DC.

ADDRESSES: Comments should be submitted in dup... attention of Air Docket No. A-92--01 at: U.S. ... Protection Agency, 401 M Street, SW., Washingt... The Public Docket is located in room M-1500, W... (Ground Floor), U.S. Environmental Protection ... Street, SW., Washington, DC. Dockets may be in... a.m. until 12 noon, and from 1:30 p.m. until 3... through Friday. A reasonable fee may be charge... docket materials.

FOR FURTHER INFORMATION CONTACT: Debbie Otting... Ozone Protection Branch, Global Change Divisio... and Indoor Air Programs, Office of Air and Rad... 401 M Street SW., Washington DC 20460. (202) 2... Stratospheric Ozone Information Hotline at 1-800-296-1996 ca... for further information on weekdays from 10:00... Time.

SUPPLEMENTARY INFORMATION: The contents of tod...

are listed in the following outline:

I. Background
  A. Ozone Depletion
  B. Montreal Protocol and EPA's Implementing Regulations
  C. Excise Tax
  D. London Amendments to the Protocol
  E. Advance Notice of Proposed Rulemaking Regarding Recycling
  F. Clean Air Act Amendments of 1990
II. Section 608 of the Clean Air Act
III. Today's Proposed Rule
  A. Equipment Affected
  B. Factors Considered in the Development of this Proposal
  C. Overview of Proposed Requirements
  D. Public Participation
  E. Definitions and Interpretations

E. Advance Notice of Proposed Rulemaking Regarding Recycling

On May 1, 1990, EPA published an advance notice of proposed rulemaking (ANPRM, 55 FR 18256) addressing issues related to the development of a national CFC recycling program. This notice emphasized that recycling is important because it would allow the continued use of equipment requiring CFCs for service past the year in which CFC production is phased out, thereby eliminating or deferring the cost of early retirement or retrofit of such equipment. The Agency continues to believe that the continued use of these substances in existing equipment that recycling would allow can serve as a useful bridge to alternative products while minimizing disruption of the current capital stock of equipment.

The ANPRM asked for comment on the feasibility of recycling in various CFC end uses and also asked for comment on methods, such as a deposit/refund system, that could be employed to encourage recycling. The Agency received 110 public comment letters in response to the ANPRM. In general, most commenters recognized the need for recycling to be established to help efforts to protect the ozone layer and to provide a source of refrigerant to service existing capital equipment after the phaseout of CFC production is complete.

Figure 5-2. The ANPRM, 55 FR 18256 Notice emphasizes the importance of recycling CFC refrigerants and allowing the continued use of equipment requiring CFCs.

To stop damage to the stratospheric ozone layer, the United States regulates, and will ultimately eliminate, the use of CFC refrigerants. By 1996, supplies of CFC refrigerants for equipment servicing were required to come from recovery and recycling measures.

Technical Fact

CLEAN AIR ACT—TABLE OF CONTENTS

Title I – Air Pollution Prevention and Control
- Part A – Air Quality and Emission Limitations
- Part B – Ozone Protection (replaced by Title VI)
- Part C – Prevention of Significant Deterioration of Air Quality
- Part D – Plan Requirements for Nonattainment Areas

Title II – Emission Standards for Moving Sources
- Part A – Motor Vehicle Emission and Fuel Standards
- Part B – Aircraft Emission Standards
- Part C – Clean Fuel Vehicles

Title III – General

Title IV – Acid Deposition Control

Title V – Permits

Title VI – Stratospheric Ozone Protection

Sec. 601. Definitions
Sec. 602. Listing of class I and class II substances
Sec. 603. Monitoring and reporting requirements
Sec. 604. Phase-out of production and consumption of class I substances
Sec. 605. Phase-out of production and consumption of class II substances
Sec. 606. Accelerated schedule
Sec. 607. Exchanges (exchange authority)
Sec. 608. National recycling and emission reduction program
Sec. 609. Servicing of motor vehicle air conditioner
Sec. 610. Nonessential products containing chlorofluorocarbons
Sec. 611. Labeling
Sec. 612. Safe alternative policy
Sec. 613. Federal procurement
Sec. 614. Relationship to other law
Sec. 615. Authority of Administrator
Sec. 616. Transfers among Parties to the Montreal Protocol
Sec. 617. Cooperation
Sec. 618. Miscellaneous (provisions)

Figure 5-3. Title VI—*Stratospheric Ozone Protection* of the Clean Air Act includes requirements for recycling and disposal of, and emissions reduction from, Class I (CFCs and Halons™) and Class II (HCFCs) substances.

CLEAN AIR ACT AMENDMENTS

The Clean Air Act Amendments (CAA) of 1990, signed November 15, 1990, included requirements for controlling ozone-depleting substances that in some cases were more stringent than those contained in the 1990 amendment of the Montreal Protocol. In addition, Title VI of the CAA includes many provisions intended to reduce emissions of ozone-depleting substances. Section 608 of the CAA promotes minimizing emissions and maximizing recycling of ozone-depleting substances. President George H. Bush announced on February 11, 1992, that the U.S. would unilaterally accelerate the phaseout schedule for ozone-depleting substances, and called upon other nations to do so as well. President Bush also asked CFC-, HCFC-, and Halon-producing countries to voluntarily reduce production of ozone-depleting substances.

Section 608 of the Clean Air Act

Amendments including the final regulations implementing Section 608 of the 1990 CAA were published on May 14, 1993, as 58 FR 28660; on August 19, 1994, as 59 FR 42950; and on November 9, 1994, as 59 FR 55912. The prohibition on venting ozone-depleting substances became effective on July 1, 1992. Under Section 608 of the CAA, the EPA has established regulations that do the following:

- Require service practices that maximize recycling of ozone-depleting substances, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), during the servicing and disposal of air conditioning and refrigeration equipment. **See Figure 5-4.**
- Set certification requirements for recycling and recovery equipment, technicians, and reclaimers.
- Restrict the sale of refrigerants only to certified technicians.
- Require persons or technicians servicing or disposing of air conditioning and refrigeration equipment to prove to the EPA that recycling and recovery equipment being used is in compliance with EPA rules.
- Require the immediate repair of substantial leaks in air conditioning and refrigeration equipment with a charge greater than 50 lb.
- Establish safe disposal requirements to ensure the removal of refrigerants from goods such as motor vehicle air conditioners, home refrigerators, and room air conditioners and prevent them from entering the waste stream with the refrigerant charge intact.

The Prohibition on Venting

Effective July 1, 1992, Section 608 of the CAA prohibits individuals from knowingly venting CFC and HCFC ozone-depleting substances into the atmosphere while maintaining, servicing, repairing, or disposing of air conditioning or refrigeration equipment (appliances). Only four types of releases are permitted under the prohibition:

- "De minimis" (minimal) quantities of refrigerant released in the course of making good faith attempts to recover, recycle, or safely dispose of refrigerant. **See Figure 5-5.**
- Refrigerant releases during the normal operation of air conditioning and refrigeration equipment, such as from mechanical purging and/or leaks. However, the EPA does require the repair of leaks above a specific size in large equipment.

- Releases of CFCs or HCFCs that are not used as refrigerants. Any heat transfer fluids are considered refrigerants. For example, mixtures of nitrogen and R-22 that are used as holding charges or as leak test gases may be released, because the ozone-depleting compound is not used as a refrigerant. However, technicians may not avoid recovering refrigerant by adding nitrogen to a charged system. Otherwise, the CFC, HCFC, HFC, or PFC vented along with the nitrogen is considered a refrigerant. Similarly, pure CFCs or HCFCs released from appliances are presumed to be refrigerants, and any release is considered a violation of the prohibition on venting.
- Small releases of refrigerant that result from purging hoses or from connecting or disconnecting hoses to charge or service appliances will not be considered violations of the prohibition on venting. However, recovery and recycling equipment manufactured after November 15, 1993, must be equipped with low-loss fittings.

The Clean Air Act allows businesses to apply for a refrigerant release permit.

▶ Technical Fact

EPA regulations require the installation of a service aperture, or process stub, on all appliances using Class 1 or Class 2 refrigerants. The main purpose of this requirement is to make it easier to recover refrigerant without leaking it to the atmosphere.

▶ Technical Fact

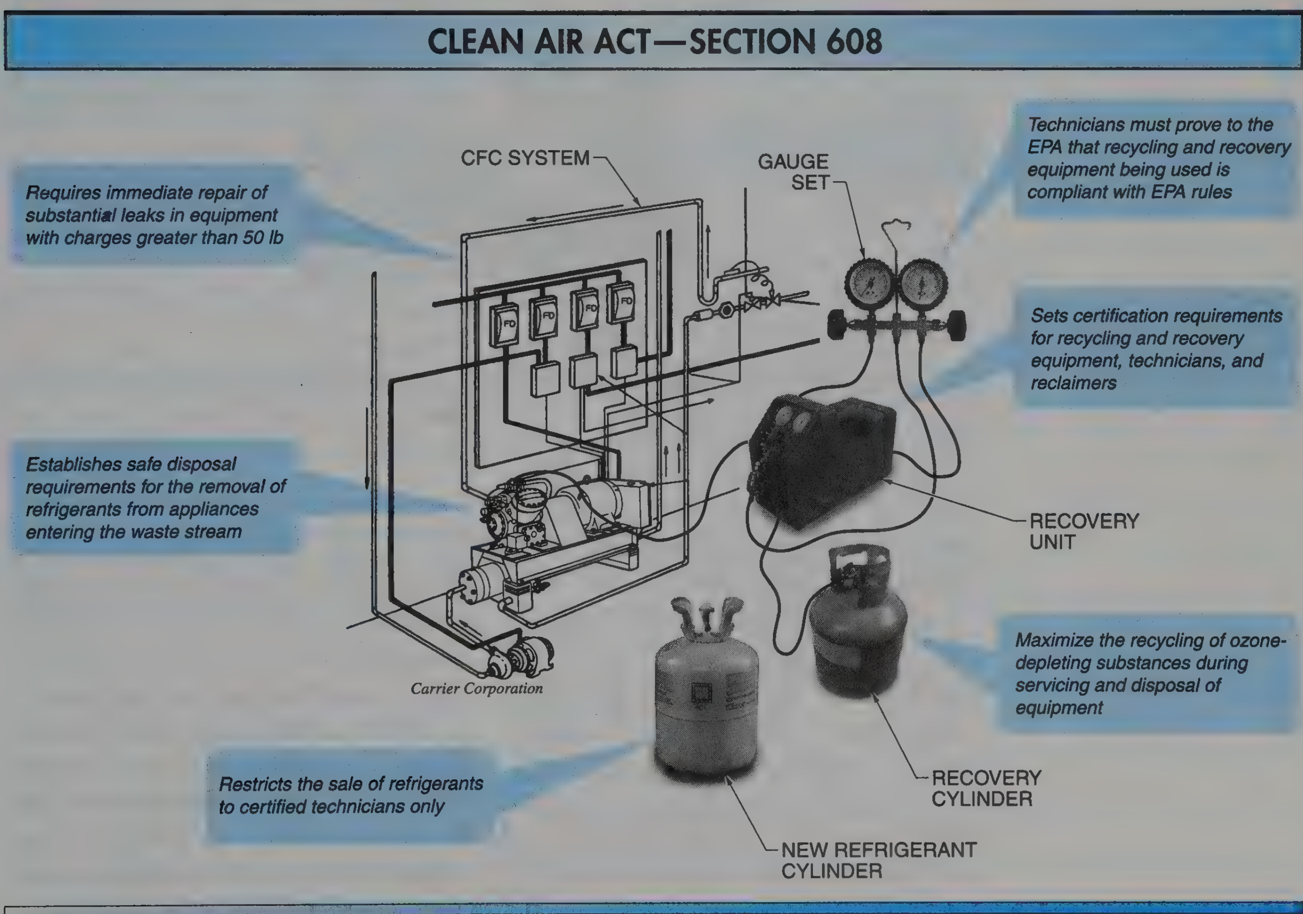


Figure 5-4. The EPA has established regulations under Section 608 of the Clean Air Act to regulate the handling of ozone-depleting substances.

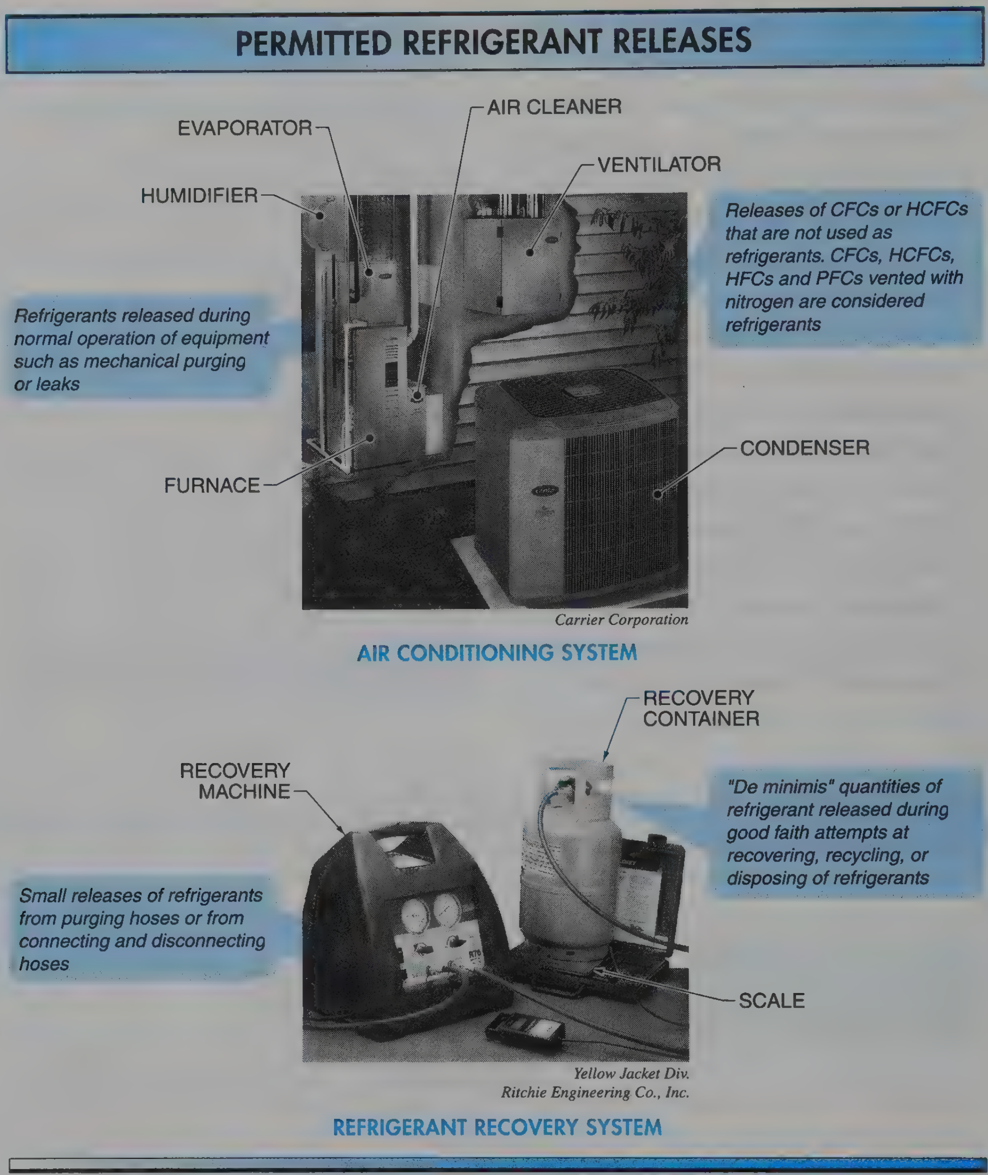


Figure 5-5. Four types of refrigerant releases are allowed under the Clean Air Act venting prohibition.

Venting Prohibition for Refrigerant Substitutes

An amendment was added in November 1995 to Section 608 of the CAA that prohibits the venting of substitute refrigerants during the maintenance, service, repair, and disposal of air conditioning and refrigeration equipment unless the EPA determines that the release of the substance does not pose a threat to the environment. The EPA considers a number of factors in making the threat determination such as the toxicity, flammability, and long-term environmental impact (ODP and GWP) of the substitute refrigerant. Also, the EPA looks at regulations under other authorities such as OSHA or from other EPA requirements that might affect the decision. Based on all the considerations, the EPA is planning to add hydrofluorocarbons (HFCs) and perfluorinated compounds (PFCs) to the types of substitute refrigerants under the venting prohibition of Section 608.

The EPA is also planning to exempt ammonia, hydrocarbons, and chlorine–which are approved for use only in industrial process refrigeration systems–and CO_2 and water refrigerants from the venting prohibition of Section 608. The planned exemptions apply only to applications of refrigerants that have been approved under the Significant New Alternatives Policy (SNAP) of the EPA. The applicability of the recycling requirements for substitute refrigerants in other applications, such as hydrocarbon refrigerants in household refrigerators, will be considered when the substitutes for specific applications are submitted for SNAP review. **See Figure 5-6.**

NOTICES AND RULEMAKINGS UNDER THE SIGNIFICANT NEW ALTERNATIVES POLICY PROGRAM

	Publication Date	Federal Register Citation	Effective Date
SNAP ANPRM	1/16/92	57 FR 1984	
SNAP Proposal	5/12/93	58 FR 28094	
SNAP Final Rule	3/18/94	59 FR 13044	4/18/94
Notice 1	8/26/94	59 FR 44240	8/26/94
Proposed Rule 12	6/3/03	86 FR 3284	6/3/03
Notice 18	8/21/03	68 FR 50533	8/21/03

Figure 5-6. The SNAP program of the EPA reviews alternatives to ozone-depleting substances.

SNAP reviewers understand that it can be dangerous to use CFC and HCFC recovery equipment to recover ammonia, hydrocarbons, or chlorine. However, users of hydrocarbons, ammonia, and pure chlorine refrigerants must continue to comply with all applicable federal, state, and local regulations on emissions of refrigerant substitutes.

Persons wishing to file a SNAP Information Notice typically spend 150 hours to generate, maintain, and provide information to the EPA.

▶ Technical Fact

Service Practice Requirements

New EPA regulations affect the way equipment is serviced. Refrigerant leak testing, recovery, evacuation, and charging must be performed with the most recent regulations in mind. All procedures that are in place for refrigerant recovery, evacuation, and charging have the intent of minimizing any system contamination and refrigerant loss.

Evacuation Requirements. Since July 13, 1993, when opening air conditioning and refrigeration equipment, technicians have been required to evacuate the equipment to established vacuum levels. If the recovery or recycling equipment being used by the technician was manufactured any time before November 15, 1993, the air conditioning or refrigeration equipment must be evacuated to specific levels described in the evacuation table. If the recovery or recycling equipment was manufactured on or after November 15, 1993, the air conditioning and refrigeration equipment must be evacuated to other specific levels described in the evacuation table. **See Figure 5-7.** An EPA-approved equipment testing organization must certify all recovery and recycling equipment. Technicians who are adding refrigerants to top off appliances or systems are not required to evacuate the systems.

The EPA is proposing to expand the list of refrigerants to include alternatives that are more climate-friendly and for those refrigerants that have a low global warming potential (GWP).

▶ Technical Fact

REQUIRED EVACUATION LEVELS		
Type of Appliance	Manufacture Date	
	Before 11/15/93†	On or After 11/15/93†
HCFC-22 appliance* normally containing less than 200 lb of refrigerant	0.0	0.0
HCFC-22 appliance* normally containing 200 lb or more of refrigerant	4.0	10.0
Other high-pressure appliance* normally containing less than 200 lb of refrigerant (CFC-12, -114, -500, -502)	4.0	10.0
Other high-pressure appliance* normally containing 200 lb or more of refrigerant (CFC-12, -114, -500, -502)	4.0	15.0
Very high-pressure appliance* (CFC-13, -503)	0.0	0.0
Low-pressure appliance* (CFC-11, HCFC-123)	25.0	29.0

* or isolated component of appliance
† in in. Hg.

Figure 5-7. Recovery and recycling equipment manufactured before November 15, 1993 removes refrigerants from air conditioning and refrigeration systems to less stringent evacuation levels than equipment manufactured after November 15, 1993.

Exceptions to Evacuation Requirements. The EPA has established limited exceptions to the evacuation requirements for repairs to leaky equipment such as repairs that are not considered major, and when evacuation of the equipment to the environment is not required. When, due to leaks, evacuation to the appropriate table levels is not attainable or would substantially contaminate the refrigerant being recovered, technicians opening an appliance must do the following:

- Isolate the leak from nonleaking components.
- Evacuate nonleaking components to the appropriate pressure levels.
- Evacuate leaking components to the lowest pressure level that can be attained without substantially contaminating the refrigerant. The lowest pressure level cannot exceed 0 psi.

If evacuation of the equipment is not to be performed when repairs are complete, and the repair is not considered major, then the appliance must meet the following requirements:

- It must be evacuated to at least 0 psi before it is opened if it is a high- or very high-pressure appliance.
- It must be pressurized to 0 psi before it is opened if it is a low-pressure appliance. Methods that require subsequent purging with nitrogen cannot be used except with appliances containing R-113 refrigerant. **See Figure 5-8.**

Reclamation Requirement. The EPA has also established that refrigerant recovered and/or recycled can be returned to the same system or other systems owned by the same person without restriction. If the refrigerant changes ownership, the refrigerant must be reclaimed

unless the refrigerant was used only in a motor vehicle air conditioner (MVAC) or MVAC-like appliance and will be used in the same type of appliance. *Reclaiming* is the cleaning and treating of a refrigerant to the ARI 700-1993 purity standard, with a chemical analysis having been performed that verifies the refrigerant is as good as new. Refrigerants used in MVACs and MVAC-like appliances are subject to the purity requirements of the MVAC regulations in 40 CFR Part 82, Subpart B.

Technician Certification

The EPA has established a technician certification program for technicians who perform maintenance, service, or repair, or who dispose of equipment that could be reasonably expected to release refrigerants into the atmosphere. The definition of the term "technician" specifically includes and excludes certain activities.

Included Activities. The definition of "technician" includes activities such as the following:

- Attaching and detaching hoses and gauges to and from an appliance to measure pressure within the appliance. **See Figure 5-9.**
- Adding refrigerant to or removing refrigerant from an appliance.
- Any activity that violates the integrity of the refrigerant circuit while refrigerant is in the system.

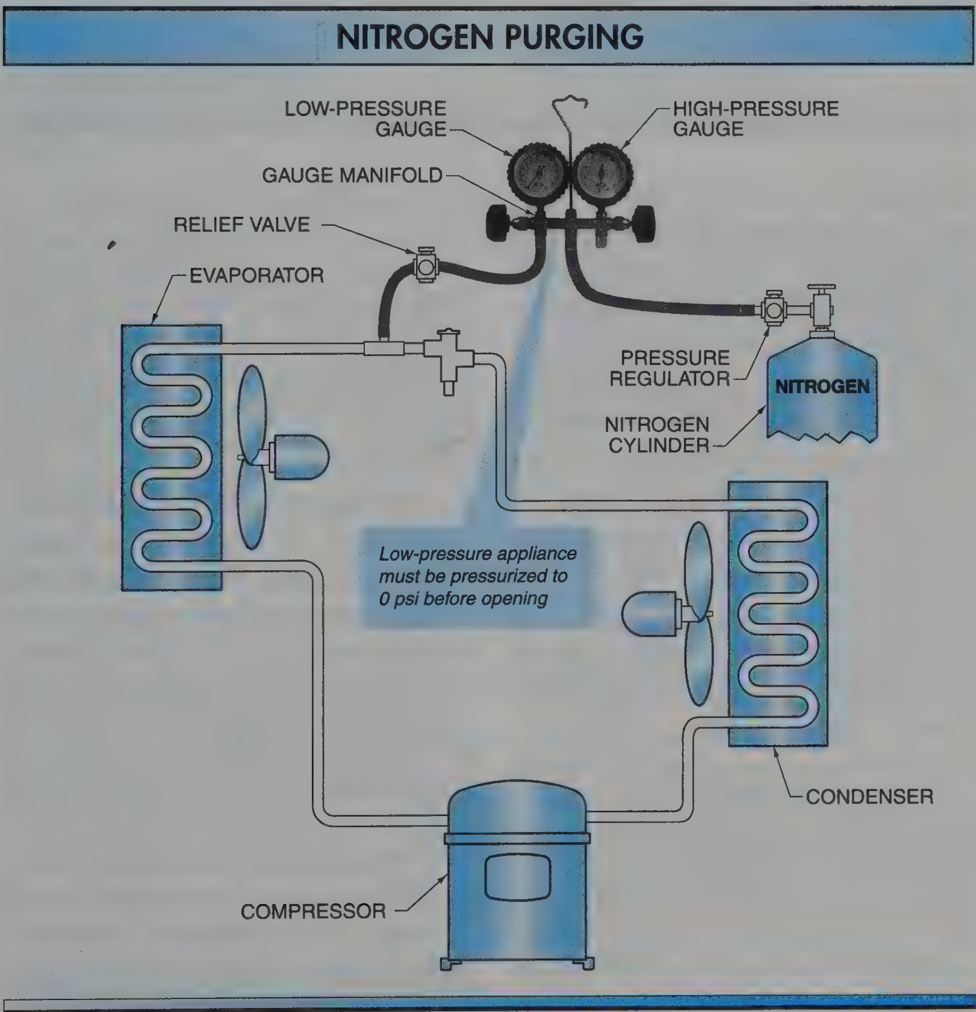


Figure 5-8. Purging pressurizes a system using a pressure source such as nitrogen. Nitrogen can also be used to pressurize a system to check for leaks.

When a relief valve is found to have internal corrosion, the valve must be replaced.

Technical Fact

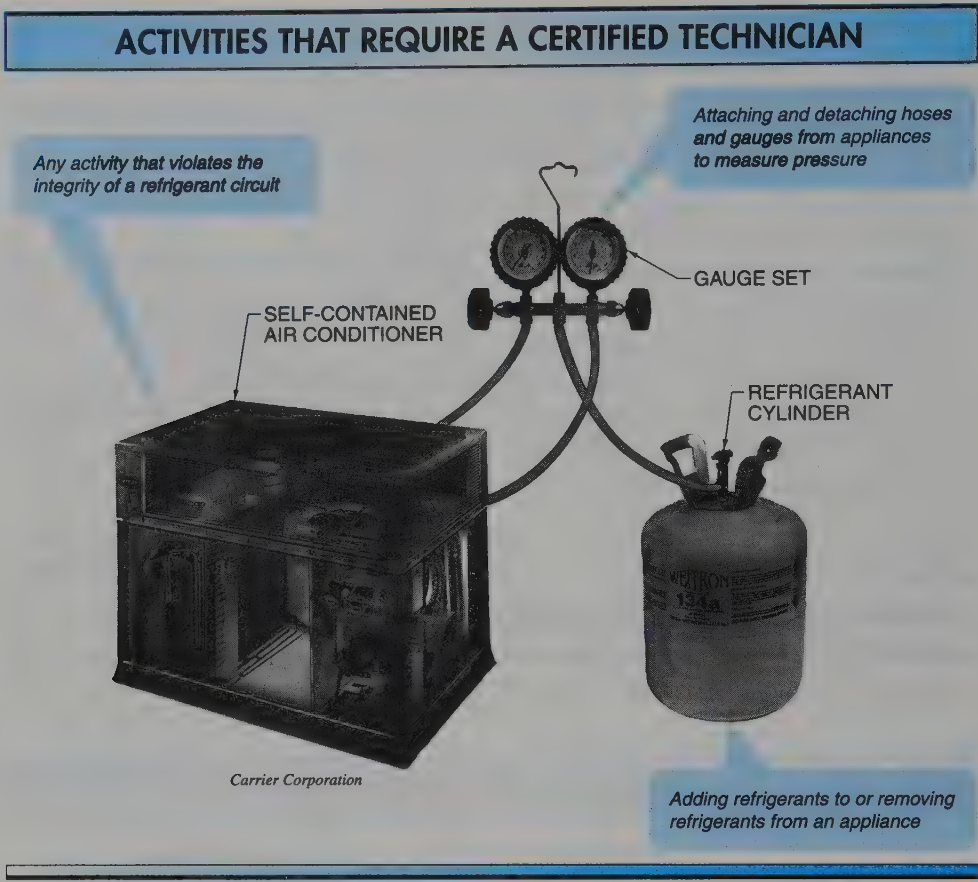


Figure 5-9. The EPA has established a technician certification program for technicians who maintain, service, repair, or dispose of equipment that could reasonably be expected to release refrigerants into the atmosphere.

Excluded Activities. The definition of "technician" excludes activities such as the following:

- Activities that are not reasonably expected to violate the integrity of the refrigerant circuit, such as painting the appliance, rewiring an external electrical circuit, replacing insulation on a length of pipe, or tightening nuts and bolts on the appliance. **See Figure 5-10.**
- Maintenance, service, repair, or disposal of appliances that have already been evacuated in accordance with EPA requirements, unless the maintenance consists of adding refrigerant to the appliance.
- Servicing MVACs, which are subject to the certification requirements of the MVAC refrigerant recycling rule. The MVAC refrigerant recycling rule falls under section 609 of the CAA.
- Disposing of MVACs, MVAC-like appliances, and small appliances.

In addition, apprentices are exempt from certification requirements provided the apprentice is closely and continually supervised by a certified technician. The EPA has four types of certification:

- servicing small appliances (Type I)
- servicing or disposing of high-pressure or very high-pressure appliances, except small appliances and MVACs (Type II)
- servicing or disposing of low-pressure appliances (Type III)
- servicing all types of equipment (Universal)

Technicians are required to pass an EPA-approved test given by an EPA-approved certifying organization to become certified under the mandatory program.

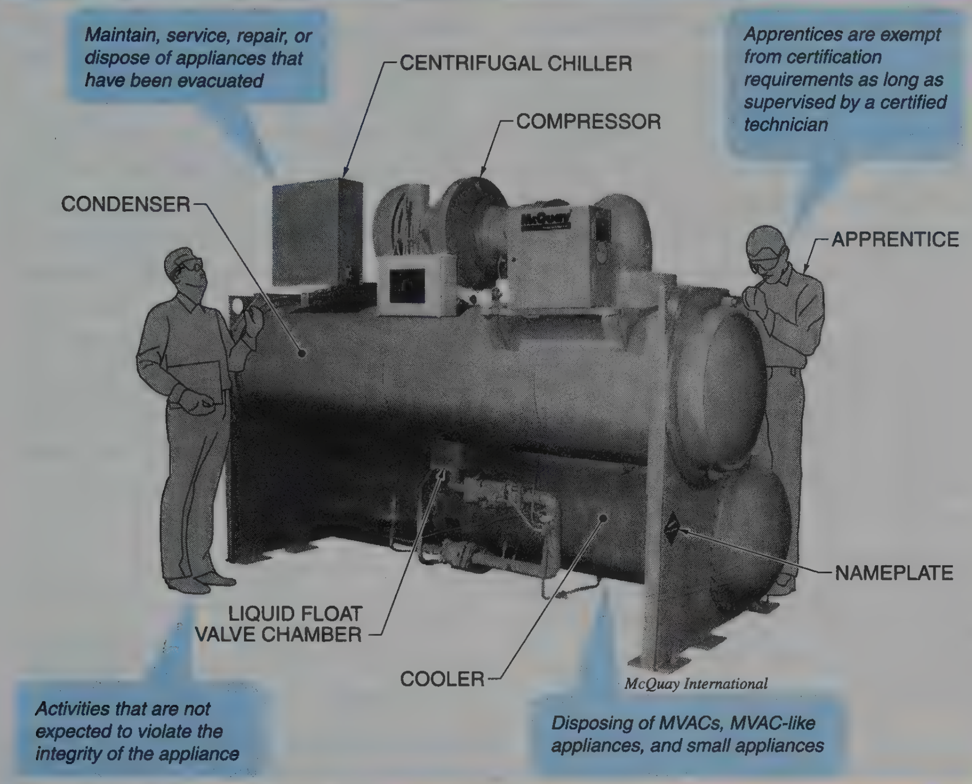


Figure 5-10. Section 608 of the Clean Air Act allows work that would not be expected to release refrigerants into the atmosphere to be performed on equipment by noncertified personnel.

Refrigerant Leaks

Owners of equipment with charges greater than 50 lb are required to repair leaks in the equipment when the total leakage results in the loss of more than a certain percentage of the equipment's charge over a year. For commercial and industrial process refrigeration sectors, leak rates that would release 35% or more of the refrigerant charge over a year must be repaired within 30 days. For all other sectors, including comfort cooling, leaks must be repaired when the appliance leaks at a rate that would release 15% or more of the refrigerant charge over a year. **See Figure 5-11.**

Refrigerant pressure in a sealed system can only be low if there is a leak in the system.

Technical Fact

APPLIANCE LEAK RATES FOR APPLIANCES WITH MORE THAN A 50 LB CHARGE

Type of System	Leak Rate*
Commercial refrigeration	35
Industrial process refrigeration	35
Comfort cooling	15
All other appliances	15

* allowed percentage of refrigerant loss per year

Figure 5-11. Owners of equipment with charges greater than 50 lb are required to repair leaks in the equipment when the total leakage results in the loss of more than 15% or 35% of the equipment's charge over a year.

The trigger for repair requirements is the leak rate instead of the total quantity of refrigerant lost. For example, a commercial refrigeration system containing 100 lb of charge must be repaired if the leaks in the system lose 10 lb or more of charge in a month.

Although 10 lb represents only 10% of the system charge, a leak rate of 10 lb per month would result in the release of 120% of the refrigerant charge over a year. The EPA mandates that owners of air conditioning and refrigeration equipment with more than 50 lb of charge must keep records of the quantity of refrigerants added to equipment during servicing and maintenance procedures.

Owners are normally required to repair leaks within 30 days of discovery. The 30-day requirement may be waived if, within 30 days of discovery, an owner develops a one-year retrofit or retirement plan for the leaking equipment. Owners of industrial process refrigeration equipment may qualify for additional time under certain circumstances. For example, if an industrial process shutdown is required to repair a leak, owners have 120 days to repair the leak.

Yellow Jacket Div., Ritchie Engineering Co., Inc.

Pinpointing a refrigerant leak source is less difficult when using a dye solution injected into the system and an ultraviolet lamp that highlights the leaking dye.

Safe Disposal Requirements

Under the rules of the EPA, equipment that is typically dismantled on-site before disposal, such as retail food freezers, residential central air conditioners, chillers, and industrial process refrigeration systems, must have the refrigerant recovered for disposal in accordance with the requirements of the EPA. However, equipment that typically enters the waste stream with the charge intact, such as motor vehicle air conditioners and household refrigerators, freezers, and room air conditioners, are subject to special safe disposal requirements.

Care must be taken in salvage yards not to vent or spill refrigerants on soil and water. Solids removed from refrigerant of scrapped air conditioners can be hazardous waste.

▶ Technical Fact

Under the safe disposal requirements, the final person in the disposal chain (scrap metal recycler or landfill owner) is responsible for ensuring that refrigerant is recovered from equipment before the final disposal of the equipment occurs. **See Figure 5-12.** However, technicians "upstream" can remove the refrigerant and provide documentation of the refrigerant removal to the final person if this is more cost-effective.

The equipment used to recover refrigerant from appliances prior to final disposal must meet the same performance standards as equipment used for servicing, but is not required to be tested by a laboratory. Equipment that is self-built is allowed as long as the equipment meets EPA performance requirements. For MVACs and MVAC-like appliances, the evacuation performance requirement is 4″ (102 mm) of mercury vacuum.

REFRIGERANT RECOVERY BEFORE APPLIANCE DISPOSAL

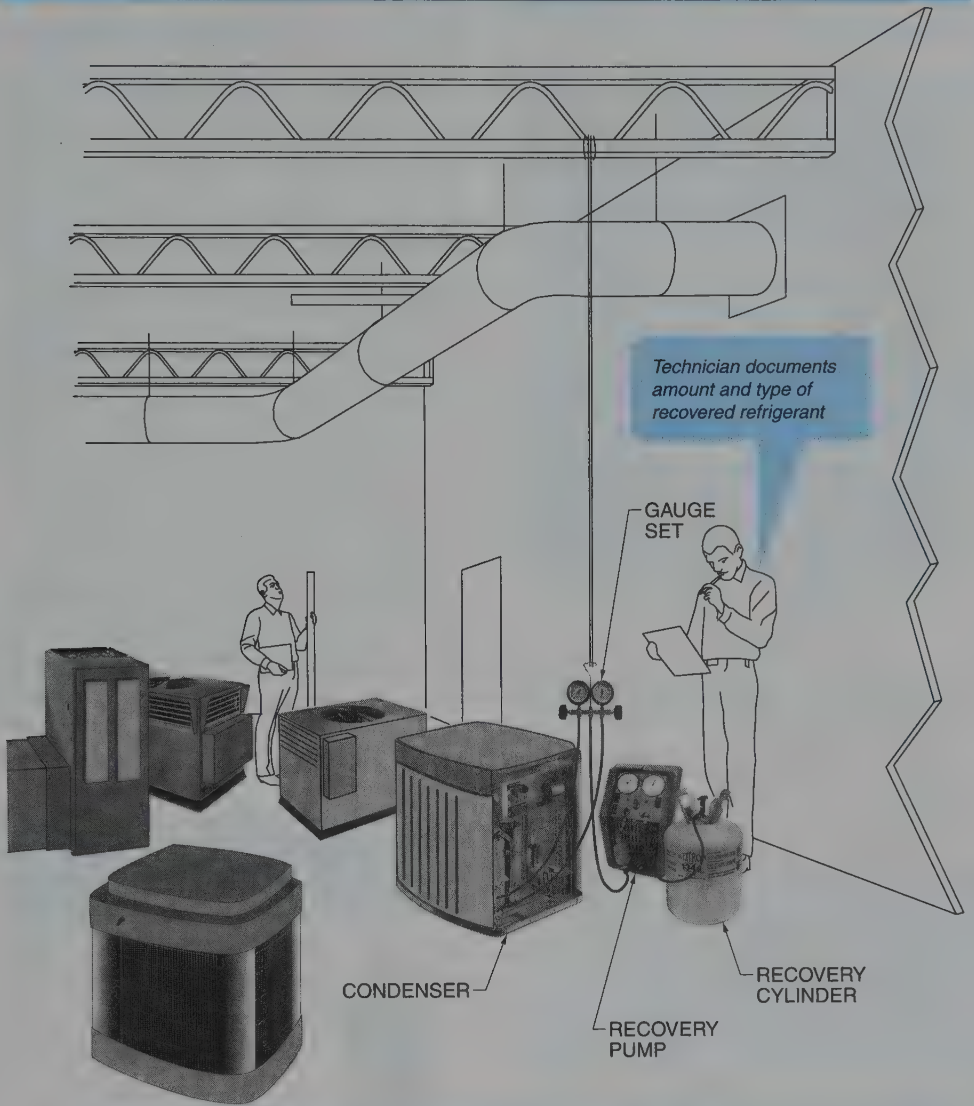


Figure 5-12. Under the safe disposal requirements for refrigerants, the final person in the disposal chain (scrap metal recycler or landfill owner) is responsible for ensuring that refrigerant is recovered from equipment before the final disposal of the equipment occurs.

For small appliances, the recovery equipment performance required is 90% efficiency when the appliance compressor is operational, and 80% efficiency when the appliance compressor is not operational.

Technician certification is not required for individuals removing refrigerant from appliances in the waste stream. The safe disposal requirements went into effect on July 13, 1993. All equipment used must be registered with or certified by the EPA.

Nonhazardous Waste Disposal. When refrigerants are recycled or reclaimed, the refrigerants are not considered hazardous under federal law. In addition, used lubricating oils contaminated with CFCs are not considered hazardous on the following conditions:

- the lubricating oil is not mixed with other waste
- the lubricating oil is subjected to CFC recycling or reclamation

- the refrigerant is not mixed with used lubricating oils from other sources

Used lubricating oils that contain CFCs after the CFC reclamation procedure are subject to specification limits for fuel oils if the lubricating oils are destined to be burned. **See Figure 5-13.**

Figure 5-13. When refrigerants or lubricating oils are recycled or reclaimed, the refrigerants or oils are not considered hazardous under federal law.

Refrigerant Sales Restrictions

Under EPA regulations, only certified technicians are allowed to purchase CFC or HCFC refrigerants. The sales restriction includes blends that have one or more components of the blend as either a CFC or HCFC. Technicians who have completed an EPA-approved certification program under either Section 608 or Section 609 are issued a certification card and are eligible to purchase refrigerants containing CFCs or HCFCs. Under Section 609 of the Clean Air Act, sales of CFC-12 refrigerants in containers smaller than 20 lb are restricted solely to technicians certified under the motor vehicle air conditioning regulations of the EPA. Persons servicing appliances under Section 608 of the Clean Air Act may still buy containers of CFC-12 refrigerant larger than 20 lb. **See Figure 5-14.**

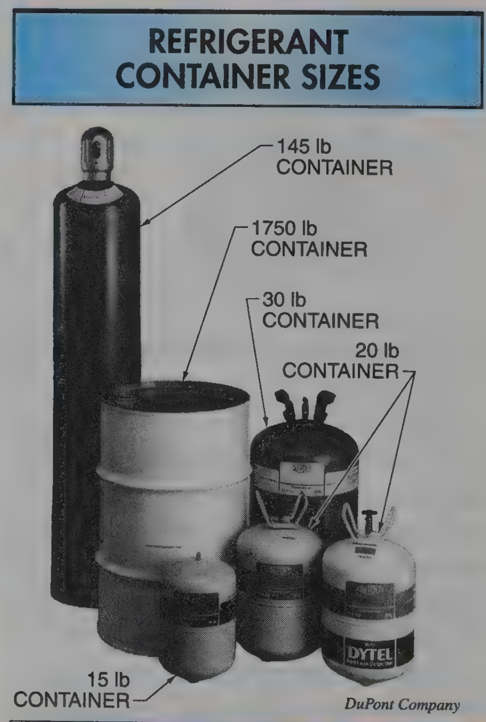


Figure 5-14. Effective November 14, 1994, the sale of refrigerants in any size container is restricted to technicians certified under Section 608, *Technician Certification* or under Section 609, *Motor Vehicle Air Conditioning* regulations.

Effective November 14, 1994, the sale of refrigerants in any size container is restricted to technicians certified under Section 608, *Technician Certification,* or under Section 609, *Motor Vehicle Air Conditioning* regulations. The sales restriction covers refrigerants contained in bulk containers such as cylinders or drums, as well as precharged units.

The sales restriction excludes refrigerants contained in sealed systems with fully assembled refrigerant circuits such as household refrigerators, window air conditioners, and packaged air conditioners. The sales restriction also excludes pure HFC refrigerants, and CFC or HCFC substances that are not intended for use as refrigerants. In addition, a restriction on the sale of precharged split systems has been stayed (suspended) while the EPA considers the implications.

Recordkeeping. Section 608 of the Clean Air Act requires that all persons who sell CFC and HCFC refrigerants retain invoices that indicate the name of the purchaser, the date of the sale, and the quantity of the refrigerant purchased. The records kept by sellers must be maintained for a minimum of three years.

Wholesalers who sell refrigerants to companies that employ certified technicians must keep proof of buyer certifications (copies of certification cards) and a list of authorized personnel or job titles/classifications who may purchase refrigerants to be used by the certified technician employed at the same company. **See Figure 5-15.**

The sale of CFC, HCFC, and blended refrigerants is strictly regulated by the EPA. HFC refrigerants such as HFC-134a are not currently subject to the same EPA rules. All records related to the sale of refrigerants must be kept for three years.

Technical Fact

Figure 5-15. Wholesalers who sell refrigerants to companies must keep proof of the certification of the refrigerant buyers.

EPA RULES FOR SELLING REFRIGERANTS TO TECHNICIANS

Selling a Large Cylinder (30 pounds) to a Refrigerant Installer

1. The seller must either see a 608 or 609 technician certification card. If the purchaser is uncertified but is purchasing for a shop or other facility, the seller must see evidence that at least one tech at that shop is certified (for example, a letter from the shop stating that Joe Tech is certified plus a copy of Joe Tech's card). The seller must keep this information on file. The purchasing facility must notify seller when Joe Tech is no longer employed.

2. The seller must get an invoice listing name of purchaser, date of sale, and quantity of refrigerant purchased.

Selling a Small Can to a Refrigerant Installer

1. The seller must see the technician's 609 certification card. Small cans may only be sold to a 609 technician. Technicians having 608 certification may not purchase small cans of ozone-depleting refrigerants.

2. The seller must get an invoice listing name of purchaser, date of sale, and quantity of refrigerant purchased.

Environmental Protection Agency

EPA RULES FOR SELLING REFRIGERANTS TO WHOLESALERS

Selling a Large Cylinder (30 lbs) to a Refrigerant Wholesaler

Recommended: The seller does not need to see a 608 or 609 card. However, it is a good idea to get a written statement certifying that the jugs will be resold, and stating name and business address of purchaser. Why? Because wholesalers are legally responsible for ensuring that people who purchase refrigerant from them are allowed under the Clean Air Act to purchase that refrigerant.

Required: The seller must get an invoice listing name of purchaser, date of sale, and quantity of refrigerant purchased.

Selling a Small Can to a Refrigerant Wholesaler

Recommended: The seller must see either a 608 or 609 technician certification card; if the purchaser is uncertified but is purchasing for a shop or other facility, the seller must see evidence that at least one tech at that shop is certified (for example, a letter from the shop stating that Joe Tech is certified plus a copy of Joe Tech's card). The seller must keep this information on file. The purchasing facility must notify seller when Joe Tech is no longer employed.

Required: The seller must get an invoice listing name of purchaser, date of sale, and quantity of refrigerant purchased.

Environmental Protection Agency

The requirements are for all refrigerant sales affected by Section 608. However, since the sale of small containers of CFC-12 refrigerants is restricted to technicians certified under Section 609, the recordkeeping requirements of Section 608 do not apply to small containers. While records must be maintained for the sale of all CFC and HCFC refrigerants in any size container, and for the sale of CFC-12 in containers 20 lb or larger, it is not necessary to maintain records for the sale of CFC-12 in small containers.

Major Recordkeeping Requirements

In addition to the regulations required above, the EPA has established major recordkeeping requirements to help with the enforcement of the Clean Air Act.

- Technicians servicing appliances that contain 50 lb or more of refrigerant must provide the owner of the appliance with an invoice that indicates the amount of refrigerant added to the appliance. Technicians must also keep a copy of their proof of certification at their place of business.
- Owners of appliances that contain 50 lb or more of refrigerant must keep service records documenting the date and type of service, as well as the quantity of refrigerant used. **See Figure 5-16.**
- Wholesalers who sell CFC and HCFC refrigerants must retain invoices that indicate the name of the purchaser, the date of sale, and the quantity of refrigerant purchased.
- Reclaimers must maintain records of the names and addresses of persons sending refrigerants and substances for reclamation and the quantity of material sent.

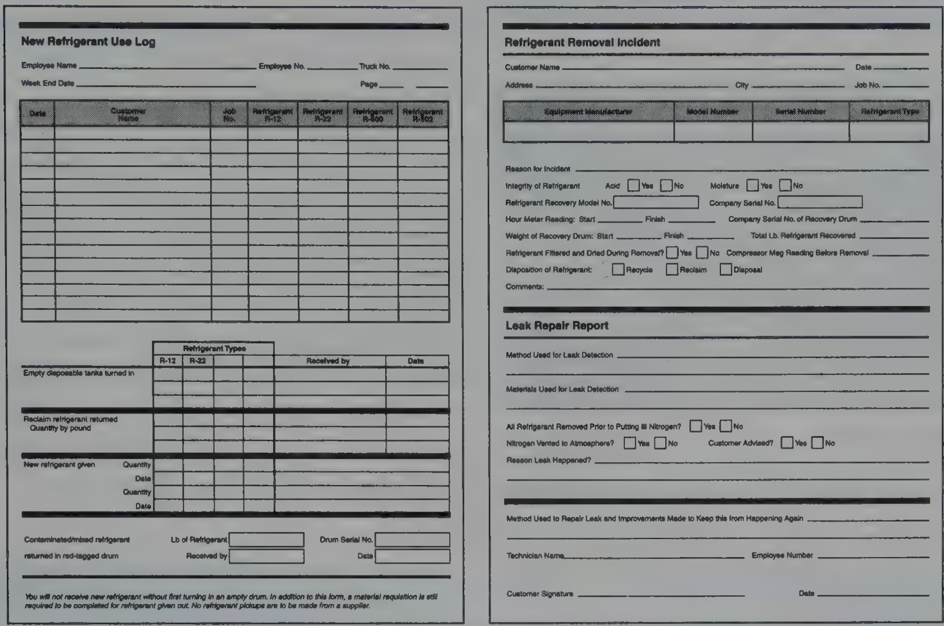
Title VI violations of the CAA have been upgraded from misdemeanors to felonies, consistent with other environmental statutes.

▶ Technical Fact

Enforcement

The EPA performs random inspections, responds to tips, and pursues potential cases against violators of Title VI of the Clean Air Act. A technician may be required to appear in federal court by the EPA. Under the Clean Air Act, the EPA is authorized to assess fines of up to $32,000 per day per violation. There are also awards, of up to $10,000, for persons furnishing information that leads to the conviction of a person violating any provision of the Clean Air Act. Once a technician is certified under Section 608, the EPA under certain circumstances can take the certification of a technician away.

SERVICE RECORD DOCUMENTATION



New Refrigerant Use Log

Employee Name ______ Employee No. ______ Truck No. ______

Week End Date ______ Page ______ ______

Date	Customer Name	Job No.	Refrigerant R-12	Refrigerant R-22	Refrigerant R-500	Refrigerant R-502

	Refrigerant Types R-12	R-22			Received by	Date
Empty disposable tanks turned in						
Reclaim refrigerant returned Quantity by pound						
New refrigerant given Quantity						
Date						
Quantity						
Date						

Contaminated/mixed refrigerant returned in red-tagged drum — Lb of Refrigerant ______ Drum Serial No. ______ Received by ______ Date ______

You will not receive new refrigerant without first turning in an empty drum. In addition to this form, a material requisition is still required to be completed for refrigerant given out. No refrigerant pickups are to be made from a supplier.

Refrigerant Removal Incident

Customer Name ______ Date ______

Address ______ City ______ Job No. ______

Equipment Manufacturer	Model Number	Serial Number	Refrigerant Type

Reason for Incident ______

Integrity of Refrigerant Acid ☐ Yes ☐ No Moisture ☐ Yes ☐ No

Refrigerant Recovery Model No. ______ Company Serial No. ______

Hour Meter Reading: Start ______ Finish ______ Company Serial No. of Recovery Drum ______

Weight of Recovery Drum: Start ______ Finish ______ Total Lb. Refrigerant Recovered ______

Refrigerant Filtered and Dried During Removal? ☐ Yes ☐ No Compressor Meg Reading Before Removal ______

Disposition of Refrigerant: ☐ Recycle ☐ Reclaim ☐ Disposal

Comments: ______

Leak Repair Report

Method Used for Leak Detection ______

Materials Used for Leak Detection ______

All Refrigerant Removed Prior to Putting in Nitrogen? ☐ Yes ☐ No

Nitrogen Vented to Atmosphere? ☐ Yes ☐ No Customer Advised? ☐ Yes ☐ No

Reason Leak Happened? ______

Method Used to Repair Leak and Improvements Made to Keep this from Happening Again ______

Technician Name ______ Employee Number ______

Customer Signature ______ Date ______

Figure 5-16. Owners of appliances that contain 50 lb or more of refrigerant must keep service records documenting the date and type of service, as well as the quantity of refrigerant used.

MVAC-LIKE APPLIANCES

Some of the air conditioners that are covered by Section 608 rules are identical to air conditioners covered by Section 609 MVAC rules. Some refrigerants are not covered by Section 609 MVAC refrigerant recycling rules (40 CFR Part 82, Subpart B) because the refrigerants used are in vehicles that are not defined as "motor vehicles." The air conditioning systems used in MVAC-like appliances include those in construction equipment, farm vehicles, boats, and airplanes. Similar to MVACs in cars and trucks, MVAC-like air conditioners typically contain 2 or 3 lb of CFC-12 refrigerant and use open-drive compressors to cool the operator compartments. **See Figure 5-17.** The EPA defines these air conditioners as "MVAC-like appliances" and applies the MVAC code requirements for the certification and use of recycling and recovery equipment.

Technicians servicing MVAC-like appliances must "properly use" recycling or recovery equipment that has been certified to meet the standards in Appendix A of 40 CFR Part 82, Subpart B. In addition, the EPA allows technicians who service MVAC-like appliances to be certified by a certification program approved under the Section 609 MVAC rule. Vehicle air conditioners utilizing HCFC-22 are not included in this group and are therefore subject to the requirements outlined for HCFC-22 equipment.

Technicians servicing MVAC-like appliances (608) have the option of becoming certified as Type II technicians instead of becoming certified as MVAC technicians under subpart B. Technicians servicing MVACs (609) do not have this choice.

Technical Fact

Violations of the Clean Air Act:

- *Falsifying or failing to keep required records*
- *Failing to reach required evacuation levels before opening or disposing of appliances*
- *Knowingly releasing CFC or HCFC refrigerants while preparing appliances*

Technical Fact

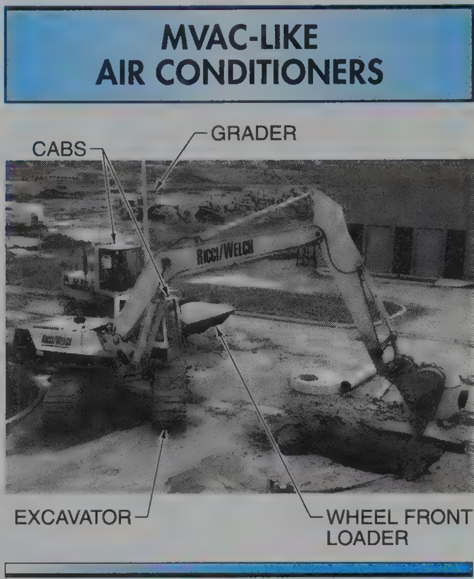


Figure 5-17. The air conditioning systems used in MVAC-like appliances include construction equipment that typically has air conditioners that contain 2 or 3 lb of CFC-12 refrigerant and use open-drive compressors to cool the operator compartment.

PLANNING AND ACTING FOR THE FUTURE

Observing the refrigerant recycling regulations of Section 608 is essential to conserving existing stocks of refrigerants, as well as complying with the Clean Air Act. However, owners of equipment that contain CFC refrigerants must look beyond the immediate need of maintaining existing equipment in working order. Owners are advised to plan for the replacement of existing equipment with equipment that uses alternative refrigerants. One possible refrigerant alternative are the hydrocarbon based refrigerants.

Discussion Questions

1. Why was the Montreal Protocol signed?
2. How did ANPRM 55 FR 18256 and the London Amendments affect the Montreal Protocol?
3. How did the Copenhagen Revisions affect CFC and HCFC refrigerant production?
4. How did the U.S. promote recycling of ozone-depleting substances?
5. What does Section 608 of the Clean Air Act (CAA) require?
6. What are the four types of releases permitted under venting prohibition?
7. Why is the date November 15, 1993 significant for evacuation of air conditioning systems?
8. Why do exceptions to the evacuation requirements exist?
9. How is the term "technician" used by the EPA?
10. How are apprentices exempt from certification requirements?
11. How do leakage rates for systems with 50 lb or more of refrigerant charge determine if repairs are required?
12. How is air conditioning and refrigerant equipment properly placed in the waste stream?
13. How do refrigerant sales restrictions work?
14. What types of records of refrigerants are kept?

Digital Resources

ATPeResources.com/QuickLinks
Access Code: 827160

REVIEW QUESTIONS

Name ______________________________ Date ______________

______ **1.** The modified Montreal Protocol phased out CFC refrigerant production in ___.

A. 1987
B. 1990
C. 1996
D. 2003

______ **2.** The Montreal Protocol is implemented in the U.S. by ___.

A. Title VI of the CAA
B. the EPA
C. the Copenhagen revisions
D. OSHA

______ **3.** The CAA, stratospheric ozone protection section, includes requirements for ___ substances.

A. all refrigerant
B. lubricating oil
C. inert
D. ozone-depleting

______ **4.** Title VI of the CAA intends to ___ of ozone-depleting substances.

A. maximize the recycling
B. extend the phaseout schedule
C. increase emissions
D. shorten the life expectancy

______ **5.** As of July 1, 1992, Section 608 of the CAA prohibits individuals from ___ CFC and HCFC ozone-depleting substances.

A. reclaiming
B. venting
C. using
D. selling

______ **6.** ___ are a type of refrigerant release permitted under the prohibition on venting.

A. Refrigerants that nitrogen has been added to
B. De minimis quantities of refrigerant released during good faith attempts
C. Releases from long hoses
D. All leaks with leak rates below 35% per year

______ **7.** The lowest pressure a leaky system can be evacuated to is ___ psi.

A. 0
B. 5
C. 10
D. 25

______ 8. Recycled refrigerant can be used by ___.

A. certified technicians without restriction

B. certified technicians in some states

C. the same owner without restriction

D. the same owner, but in another state

______ 9. Owners of comfort cooling equipment with 50 lb or more of refrigerant charge must repair leaks that have leak rates greater than ___% per year.

A. 15

B. 25

C. 35

D. any

______ 10. Air conditioning and refrigeration equipment owners are required to repair leaks that require the system to be shut down, within ___ days.

A. 2

B. 14

C. 30

D. 120

______ 11. Under the safe disposal requirements of the CAA, the final person in the disposal chain is responsible for ___ refrigerant before the final disposal of equipment occurs.

A. recycling

B. recovering

C. reclaiming

D. destroying

______ 12. Technicians certified under Section 608 of the CAA cannot purchase refrigerants in containers smaller than ___ lb.

A. 5

B. 20

C. 30

D. 145

______ 13. The recordkeeping requirements of Section 608, concerning the selling of refrigerants, do not apply to ___.

A. reclaimed refrigerants

B. Halons™

C. small cans of CFC-12

D. drums of any refrigerant

______ 14. Under the CAA, the EPA is authorized to assess fines of up to $___ per day per violation.

A. 1200

B. 5000

C. 10,000 $2000

D. 27,500

______ 15. MVAC-like air conditioners typically have ___ lb of refrigerant charge.

A. 2 or 3

B. 5

C. 15

D. 50 or more

6 Recovery, Recycling, and Reclaiming

Recovery, recycling, and reclaiming are service activities that technicians perform. Each of these activities require specific procedures and documentation to comply with EPA regulations. Refrigerant recovery and recycling equipment must be tested as specified by the EPA certification program.

RECOVERY, RECYCLING, AND RECLAIMING

The terms "recovery," "recycling," and "reclaiming" refer to activities that technicians perform with refrigerants of air conditioning and refrigeration systems. Not only has the EPA eliminated production of Class I (CFCs and Halons) and Class II (HCFCs) substances, the EPA also requires refrigerants properly contained to ensure that Class I and Class II substances (refrigerants) can be reused. When addressing consumer questions regarding additional service expenses due to recovery efforts, technicians must explain that the recovery of refrigerants is required by law to protect human health and the environment. The duty of all air conditioning and refrigeration technicians is to follow the law and protect the environment from the release of refrigerants to the atmosphere. **See Figure 6-1.**

All devices (pumps, gauges, valves, recovery cylinders, hoses, and scales) used for refrigerant recovery must meet EPA standards.

Technical Fact

SPX Robinair

Recovery machines come in many manufactured designs, and many other designs that are certified one-of-a-kind recovery machines.

TECHNICIAN DUTY – PROTECTING THE ENVIRONMENT

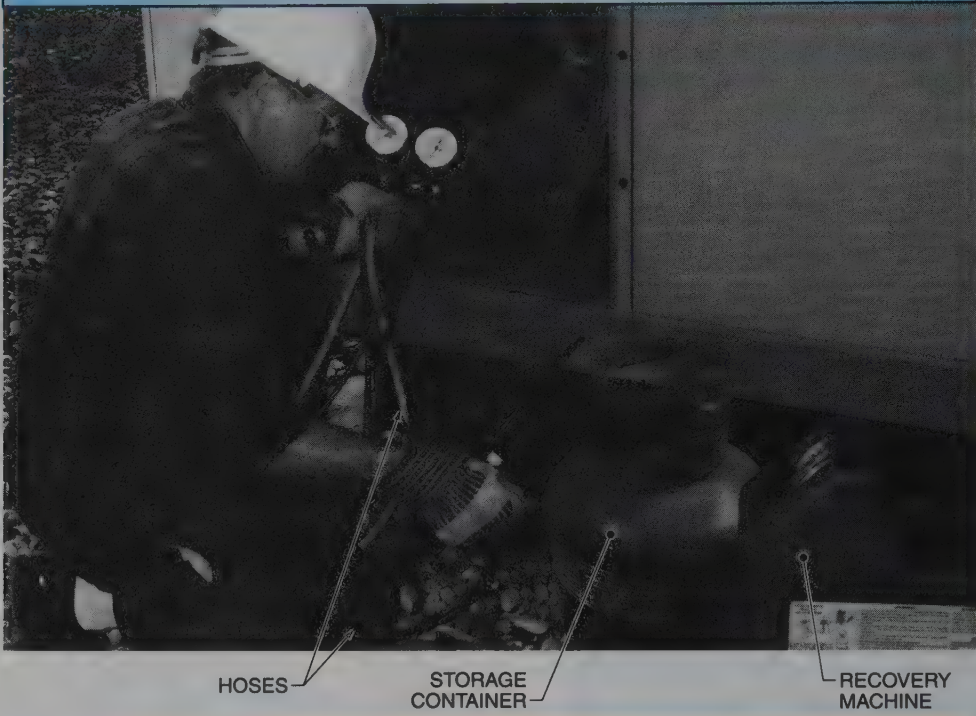


Figure 6-1. Refrigerant recovery procedures performed by the technician and equipment must comply with EPA regulations.

CFC RECOVERY, RECYCLING, AND RECLAIMING

CFC substances have not been manufactured since 1995. After 1995, supplies of CFC refrigerants for equipment servicing have come from recovery and recycling efforts. As time passes, CFC refrigerants will become harder to obtain. As CFC refrigerants become less available, CFC refrigerants will become too expensive to use.

System-dependent (passive method) refrigerant recovery captures refrigerant with the assistance of components in the refrigeration system.

▶ Technical Fact

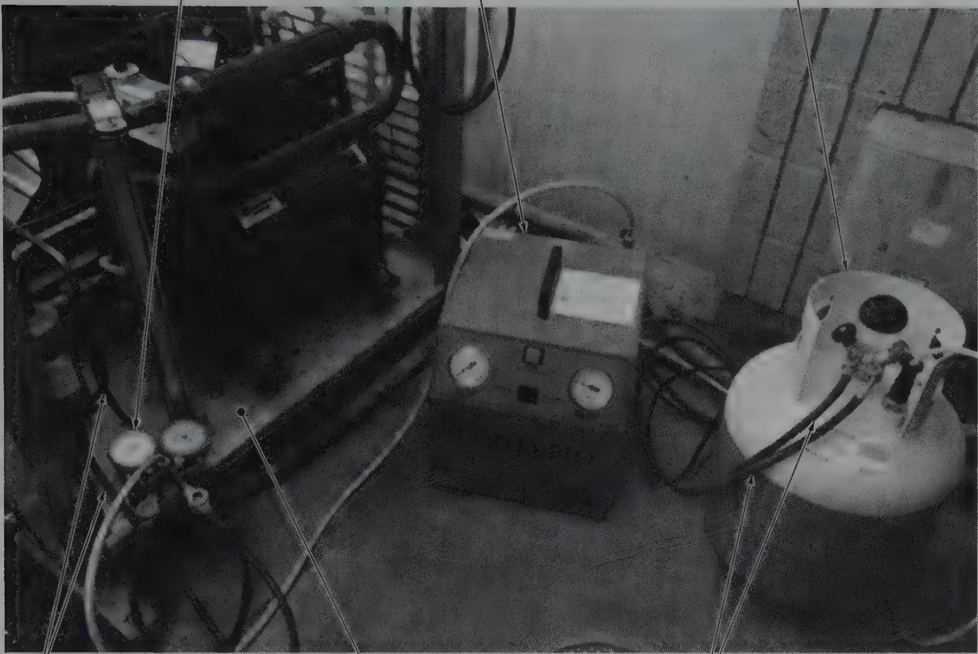
Recovery

Refrigerant recovery is the removal of refrigerant in any condition from a system without testing or processing the refrigerant and storing the refrigerant in an external container. The recovery of refrigerants is necessary to ensure adequate supplies of refrigerants for present and future service use after production bans are in effect. Recovering refrigerants also prevents the venting of refrigerants to the atmosphere and ozone depletion. **See Figure 6-2.** Refrigerant must be recovered during the service of a refrigeration system containing Class I or Class II refrigerants. Recovery can be achieved by using passive or active methods.

Passive Recovery. *Passive recovery* is a refrigerant recovery process achieved with the assistance of system components to remove the refrigerant from the system (pump-down). The passive recovery method can only be used with appliances designed to use 15 lb or less of refrigerant.

Recovery equipment must be checked for leaks every six months by a method approved by the Executive Officer designee of the EPA. Leaks shall be repaired within two working days after the leak is first detected, unless the equipment does not leak due to discontinued use.

▶ Technical Fact



ATOFINA Chemical Co.

Figure 6-2. Refrigerant recovery is the removal of refrigerant from a system without testing or processing the refrigerant in any way and storing the refrigerant in an external container.

Refrigerant must be recovered during the service of a refrigeration system containing a CFC or HFC (R-12 or R-22) refrigerant. All CFC or HCFC (R-12, R-22, and R-502) refrigerants must be recovered before disposing of an appliance.

▶ Technical Fact

Active Recovery. *Active recovery* is a refrigerant recovery process using a self-contained recovery unit (machine). The active recovery method is the most popular method. The recovery unit removes the refrigerant with no assistance from system components.

Recycling

Refrigerant recycling is the removal of refrigerant from a system and the cleaning of the refrigerant for reuse. Recycled refrigerant is refrigerant that has been processed using oil separators and single- or multiple-pass filter-dryers to separate moisture, acidity, and particulate matter from the refrigerant. **See Figure 6-3.** Recycling procedures are typically implemented at the job site, and do not require the refrigerant to be tested to ensure quality.

EPA PROPOSED STANDARDS

III. Scope of Statutory and Proposed Regulatory Requirements

Overview of Proposed Requirements

1. HFCs and PFCs

EPA is proposing to extend the regulatory framework for CFCs and HCFCs to HFCs and PFCs, making appropriate adjustments for the varying physical properties and environmental impacts of these refrigerants. Thus, appliances containing HFC or PFC refrigerants would have to be evacuated to established levels; recycling and recovery equipment used with HFCs or PFCs would have to be certified (although existing recovery equipment that met certain minimum standards would be grandfathered); technicians who work with HFCs or PFCs would have to be certified (although technicians who have been certified to work with CFCs and HCFCs would be grandfathered); sales of HFC and PFC refrigerants would be restricted to certified technicians; used HFC and PFC refrigerants sold to a new owner would have to be tested to verify that they meet industry purity standards; refrigerant reclaimers who purify HFCs or PFCs would have to be certified; owners of HFC and PFC appliances above a certain size would have to repair leaks above a certain size; final disposers of small appliances and motor vehicle air conditioners (MVACs) containing HFCs or PFCs would have to ensure that refrigerant was recovered from this equipment before it was disposed of; and manufacturers of HFC and PFC appliances would have to provide a servicing aperture or a "process stub" on their equipment in order to facilitate recovery of the refrigerant.

Environmental Protection Agency

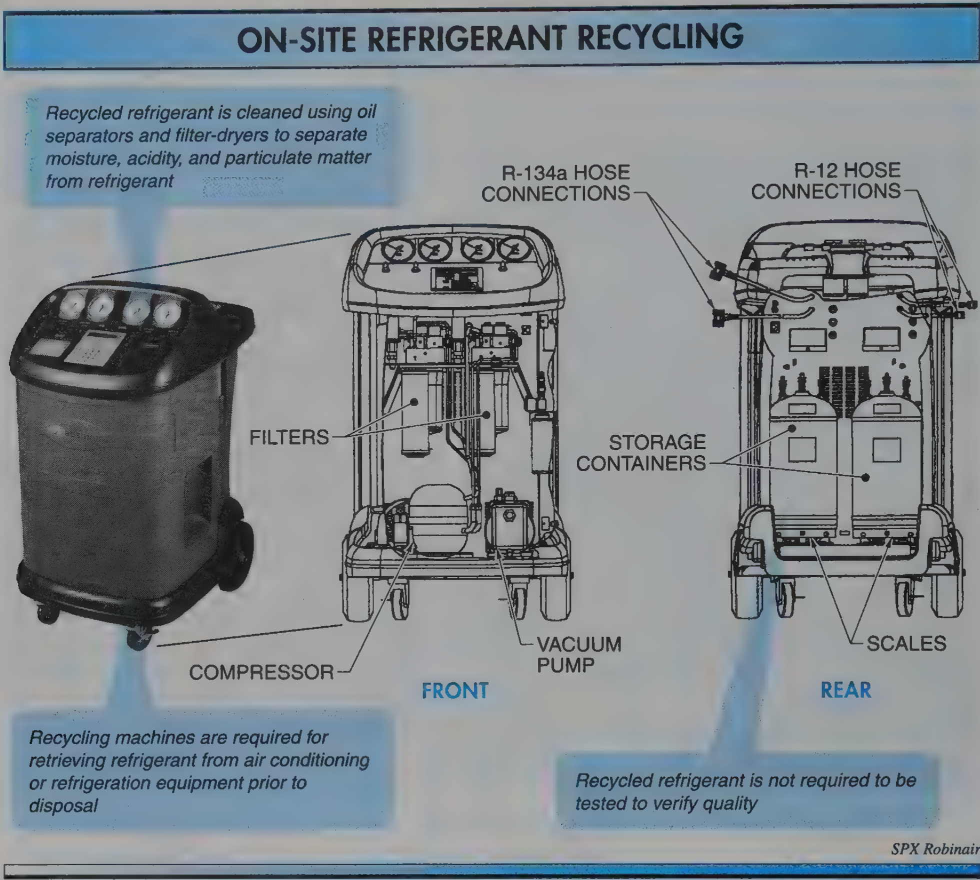


Figure 6-3. Refrigerant recycling is the removal of refrigerant from a system and the cleaning of the refrigerant for reuse in the process.

When recycled refrigerant has been added to a system, a sample of the lubricating oil should be taken for analysis.

▶ Technical Fact

Recovery and Recycling Equipment. Recovery and recycling equipment is purchased for use in the field. Recovery and recycling machines are required when servicing or disposing of air conditioning or refrigeration equipment.

Reclaiming

Refrigerant reclaiming is the reprocessing of used refrigerant to meet new refrigerant standards and includes chemical analysis to verify purity. In some cases, refrigerant removed from a system cannot be reused or recycled. Reclaiming is necessary if a refrigerant is heavily contaminated, if the quality is unknown, or if recycling equipment is unavailable. **See Figure 6-4.** Reclaimed refrigerant must be processed to the purity specifications in Standard 700-1993 of the Air Conditioning and Refrigeration Institute (ARI). Purity must be verified using laboratory analysis. No more than 1.5% of the refrigerant may be released to the atmosphere during the reclaiming process. Reclamation of a refrigerant involves procedures that are only available using refrigerant reprocessing equipment or at a refrigerant manufacturing facility. To reclaim refrigerant, the refrigerant must be sent to an EPA-certified reclamation facility or reclaimed by using certified reclamation equipment.

The purpose of ARI Standard 700 is to set purity specifications for reclaimed refrigerants. The number of refrigerants specified has increased: in 1988, nine refrigerants were in use; in 1993, 20; in 1995, 36; in 1999, 43; and in 2003, approximately 60 refrigerants were in use.

▶ Technical Fact

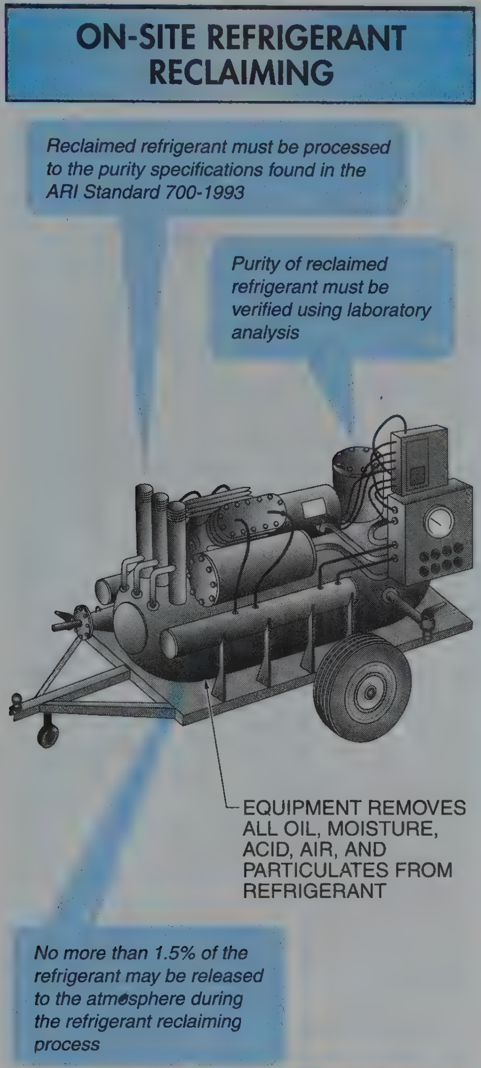


Figure 6-4. Refrigerant reclaiming is the reprocessing of used refrigerant to meet new refrigerant standards and includes chemical analysis to verify purity.

Refrigerants that are seriously contaminated cannot be reclaimed. Refrigerants with serious contaminants, such as acid contaminants created from burnouts, are the most difficult for a reclaiming facility to handle successfully. When recovering refrigerant, it is important not to mix different refrigerants in the same container because most refrigerant mixtures are impossible to reclaim. Refrigerants that cannot be separated must be destroyed. Refrigerants should never be mixed.

ARI STANDARD 700-1999 (SPECIFICATION FOR FLUOROCARBON REFRIGERANTS)

Section 1. Purpose
1.1 Purpose. The purpose of this standard is to establish purity specifications and specify the associated methods of testing for acceptability of fluorocarbon refrigerants regardless of source (new, reclaimed, and/or repackaged) for use in new and existing refrigeration and air conditioning products within the scope of ARI.
1.1.1 Intent. *This standard is intended for the guidance of the industry including manufacturers, refrigerant reclaimers, repackagers, distributors, installers, serviceman, contractors, and users.*
Section 2. Scope. . . .
Section 3. Definitions. . . .
Section 4. Characterization of Refrigerants and Contaminants
4.1 Characterization. *Characterization of refrigerants and contaminants addressed are listed in the following general classifications:*
- *4.1.1* Identification.
  - *a. Gas chromatography*
  - *b. Boiling point and boiling point range*
- *4.1.2* Contaminants.
  - *a. Water*
  - *b. Chloride*
  - *c. Acidity*
  - *d. High boiling residue*
  - *e. Particulates/solids*
  - *f. Non-condensables*
  - *g. Volatile impurities/refrigerants*

Section 5. Sampling and Summary of Test Procedures. . . .
Section 6. Reporting Procedures. . . .
Section 7. Voluntary Conformance. . . .

Reclaimer Certification

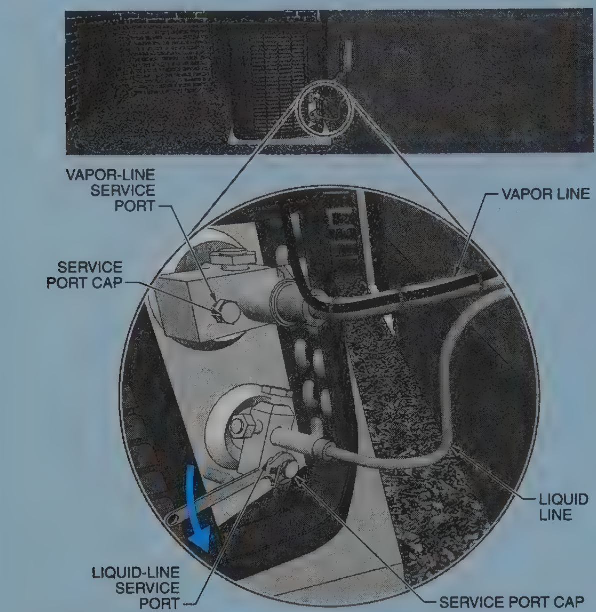
Reclaimers must certify to the Recycling Program Manager of the EPA that procedures and reclaiming equipment being used comply with the applicable requirements of ARI Standard 700. The certification of the reclaimer must be signed by the owner of the equipment or other responsible officer and sent to the appropriate EPA regional office. Refrigerant reclaimers are required to return refrigerants to the purity level specified and to verify the purity of the refrigerants using laboratory protocols. In addition, reclaimers must properly dispose of all wastes from the reclamation process.

The EPA standard 40 CFR Part 82, Protection of Stratospheric Ozone, *provides information on refrigerants that are transferred between appliances with different ownership. This information is also found in the ARI standard 740.*

▶ Technical Fact

Accessing Service Port Schrader Valves Procedure

1. Remove service port cap with adjustable wrench.

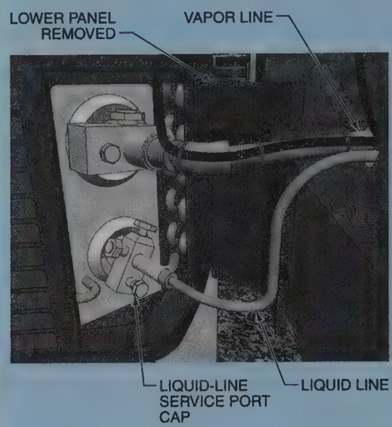


2. Connect gauge to service port.

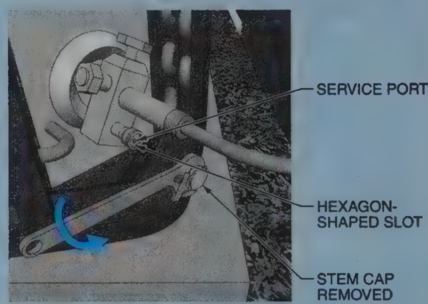
3. When testing is complete, replace service port cap. Tighten finger-tight and then tighten an additional ⅙ turn.

Opening Liquid-Line or Suction-Line Service Valves Procedure

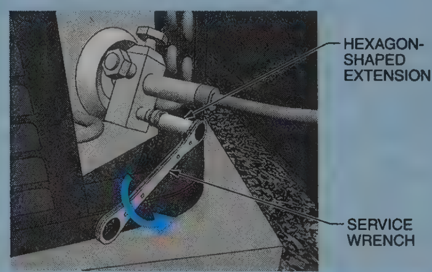
1. Gain access to service valve.



2. Remove stem cap with adjustable wrench.

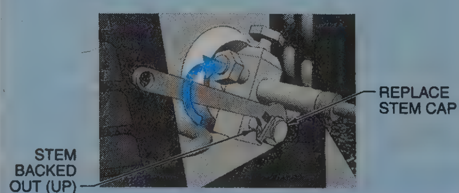


3. Use service wrench with hex-head extension to back stem out counterclockwise as far as it will go.



Note: Use 3/16″ hex-head extension for liquid-line service ports and 5/16″ hex-head extension for suction-line service ports.

4. Replace stem cap. Tighten finger-tight and then tighten an additional ⅙ turn.

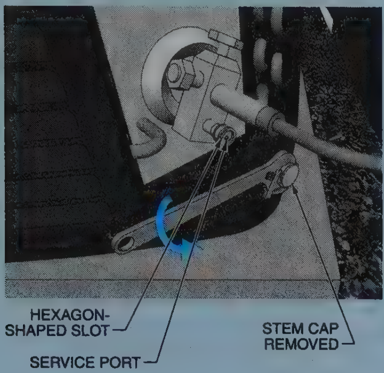


Reclamation Requirements

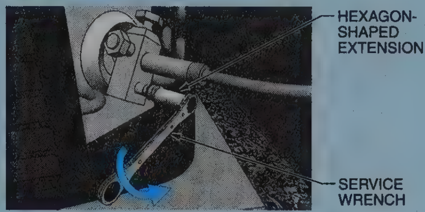
The EPA has established that recovered and/or recycled refrigerant can be returned to the same system or other systems owned by the same person without restriction. If refrigerant changes ownership, the refrigerant must be reclaimed unless the refrigerant was used only in a motor vehicle air conditioner (MVAC) or MVAC-like appliance and will be used in the same type of appliance again.

Closing Liquid-Line or Suction-Line Service Valves Procedure

1. Remove service port cap with adjustable wrench.

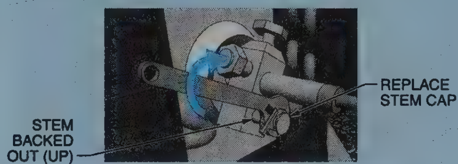


2. Use service wrench with hex-head extension to turn stem clockwise to seat valve. Tighten firmly.



Note: Use 9/16″ hex-head extension for liquid-line service ports and 5/16″ hex-head extension for suction-line service ports.

3. Replace stem cap. Tighten fingertight and then tighten an additional 1/6 turn.



Within 20 days of commencing business and by January 15 of each year, appliance recyclers must certify to the EPA that certified technicians are operating proper refrigerant recovery equipment. A machine certification form is filled out and sent to the EPA regional office in Chicago by certified mail.

▶ Technical Fact

Evacuation Levels

Each type of system (small appliance, high-pressure, and low-pressure) has evacuation level (vacuum) requirements. When using recovery and recycling equipment the percentage of refrigerant that can be removed from a system is directly related to the amount of vacuum that the recovery or recycling equipment can achieve.

REFRIGERANT HANDLING OPTIONS

The options a technician has when working with refrigerants are to recover refrigerant, recycle refrigerant, reclaim refrigerant, or have the refrigerant destroyed. The condition of the refrigerant determines the best option. If the refrigerant is in satisfactory condition, the technician can recover the refrigerant. If the refrigerant is in an unsatisfactory condition, reclamation may be required. **See Figure 6-5.**

REFRIGERANT PROCESSES

Activity	Use
Recover	Method to use when refrigerant is in excellent condition
Recycle	Method to use when refrigerant is in good condition
Reclaim	Method to use when refrigerant is in poor condition
Destroy	Method to use when refrigerant is beyond reclaiming

Figure 6-5. The options a technician has when working with refrigerants are to recover, recycle, reclaim, or destroy the refrigerant.

Refrigerant recovery during low ambient temperatures will slow the recovery process. Long hoses between the refrigeration unit and the recovery machine must be avoided as they result in the following:

- *Excessive pressure drops*
- *Increase recovery time*
- *Increase emissions (when refrigerant escapes)*

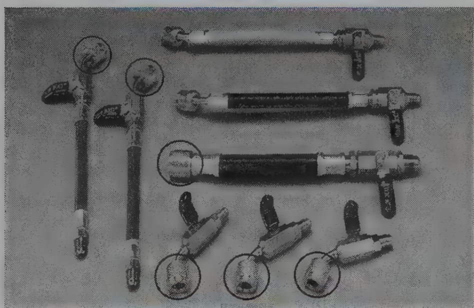
▶ Technical Fact

Low-Loss Fittings

Low-loss fittings are special fittings that prevent the release of refrigerant from a system to the atmosphere and prevent air from entering the system. **See Figure 6-6.** Low-loss fittings automatically trap refrigerant in a hose when disconnected and are required on all recovery, recycling, and reclaiming equipment.

LOW-LOSS FITTINGS

COMMON FITTING SHAPES



FITTINGS WITH VALVES

Yellow Jacket Div., Ritchie Engineering Co., Inc.

Figure 6-6. Low-loss fittings are intended to prevent the release of refrigerant from a system to the atmosphere and to prevent air from entering a system.

EQUIPMENT CERTIFICATION

The EPA has established a certification program for recovery and recycling equipment. Under the program, the EPA requires that recovery and recycling equipment manufactured on or after November 15, 1993, be tested by an EPA-approved testing organization to ensure that the equipment meets EPA requirements. Recovery and recycling equipment intended for use with air conditioning and refrigeration equipment must be tested under the ARI 740-1993 test protocol. Recovery equipment intended for use with small appliances must be tested under the ARI 740-1993 final rule protocol.

The EPA requires recovery efficiency standards that vary depending on the size and type of air conditioning or refrigeration system being serviced. The recovery and recycling equipment intended for use with air conditioning and refrigeration systems must be able to recover a specific percentage of refrigerant or create a specific level of vacuum on the system. For example, the recovery equipment intended for use with small appliances must be able to recover 80% or 90% of the system refrigerant depending on if the compressor is operating. **See Figure 6-7.**

SMALL APPLIANCE REFRIGERANT RECOVERY

80% Recovery required	90% Recovery required
Technician uses recovery or recycling equipment manufactured before November 15, 1993	Technician uses recovery or recycling equipment manufactured on or after November 15, 1993
Compressor of the appliance is not operating	Compressor of the appliance is operating

Figure 6-7. The recovery equipment intended for use with small appliances must be able to recover 80% or 90% of the refrigerant.

The EPA has approved the ARI and Underwriters Laboratories (UL) to certify recycling and recovery equipment. Certified equipment is identified by a label signifying compliance with ARI Standard 740. **See Figure 6-8.**

Technicians operating recovery or recycling equipment must wear safety glasses and protective gloves, and follow all equipment safety precautions.

▶ Technical Fact

ARI STANDARD 740 EQUIPMENT CERTIFICATION LABEL

Air Conditioning and Refrigeration Institute

Figure 6-8. Certified equipment is identified by a label signifying compliance with ARI Standard 740.

Certification of Owners of Recycling and Recovery Equipment

The EPA requires that persons servicing or disposing of air conditioning and refrigeration equipment certify to the appropriate EPA regional office that recovery and/or recycling equipment has been acquired (built, bought, or leased) and that the equipment complies with the applicable requirements of Section 608. Recovery and recycling equipment certification is typically performed by a third party recognized by the EPA.

Equipment Grandfathering

Equipment manufactured before November 15, 1993, including homemade equipment, may be grandfathered if the equipment meets the standards in the evacuation requirement tables. Third-party testing is not required for equipment manufactured before November 15, 1993, but equipment manufactured on or after November 15, 1993, including homemade equipment, must be tested by an EPA recognized third party.

USE OF CFC AND HCFC RECOVERY EQUIPMENT WITH HFC AND PFC REFRIGERANTS

All recovery equipment now manufactured must have an EPA approval label or stamp on the body of the equipment. Manufacturers of recycling and recovery equipment have stated that most recovery and recycling equipment designed for use with multiple CFC or HCFC refrigerants (R-12, R-22, R-500, and R-502) can be adapted for use with HFC and PFC refrigerants with similar saturation pressures.

The EPA plans to allow technicians to recover HFC and PFC materials using recovery or recycling equipment designed for use with at least two CFC or HCFC refrigerants of similar saturation pressures. The recovery equipment would have to meet specific standards and if the recovery equipment was manufactured on or after November 15, 1993, the equipment would have to be certified by an EPA-approved third-party certification program (ARI or UL) for at least two refrigerants with saturation pressures similar to the saturation pressure of the refrigerant(s) with which the equipment is to be used.

In some cases, manufacturers recommend changing the lubricant in recovery or recycling equipment from mineral oil to a polyol ester lubricant (POE). In other cases, no lubricant change is necessary. Individuals who intend to use existing CFC or HCFC recovery equipment with HFC refrigerants must contact the recovery equipment manufacturer to determine what changes must be made to the equipment.

Upon completion of a refrigeration liquid transfer between the refrigeration system to the recovery unit, a technician should avoid trapping liquid refrigerant between the service valves.

▸ Technical Fact

All refrigerant recovery equipment manufactured today require an EPA approved certification label.

▸ Technical Fact

Manchester Tank & Equipment Co.

Refrigerant containers (cylinders) come in a variety of sizes. Typically, manufacturers have 15 lb, 20 lb, 30 lb, 100 lb, 125 lb, 250 lb, 500 lb, and 1000 lb refrigerant containers available.

CONTAINER COLOR CODING

Refrigerant Number	Chemical Composition	Container Color
R-11	CFC	Orange
R-12	CFC	White
R-13	CFC	Medium blue
R-13B	CFC	Coral
R-22	HCFC	Light green
R-23	HFC	Light gray
R-113	CFC	Purple
R-114	CFC	Dark blue
R-123	HCFC	Medium gray
R-124	HCFC	Deep green
R-125	HFC	Medium brown
R-134a	HFC	Light (sky) blue

Figure 6-9. Refrigerant containers are color-coded according to the type of refrigerant.

REFRIGERANT CONTAINERS

Refrigerant containers are disposable or reusable. A *disposable container (cylinder)* is a container used only with new refrigerants. Disposable containers are designed for refrigerant extraction and are not used to receive refrigerants. Disposable containers such as DOT 39 are not to be reused under any circumstances.

After use, disposable containers must be disposed of properly. Before disposing a disposable cylinder, the internal pressure of the cylinder must be reduced to 0 psi. All refrigerant must be recovered and the empty disposable container is then scrapped as metal. Disposable refrigerant containers are color-coded according to the type of refrigerant in the container. **See Figure 6-9.**

A *reusable container (cylinder)* is a gray container with a yellow top designed to receive refrigerant and have refrigerant extracted. For example, storage cylinders can have the internal pressure of the cylinders rise in heated areas and cause an explosion. Refrigerant storage cylinders can be filled to a maximum of 80% capacity. To ensure 80% capacity when transferring refrigerant to an empty or pressurized cylinder, the safe filling level is controlled by a mechanical float device, by weighing the cylinder using a scale, or electronic shutoff devices. **See Figure 6-10.** A refrigerant label is placed on cylinders and containers to identify the type of refrigerant in the container and the gross weight of the container. When transporting cylinders containing used refrigerant, the Department of Transportation (DOT) requires that DOT classification tags be attached to the containers. **See Figure 6-11.** When shipping refrigerant cylinders, the cylinders must always be in an upright position. When recovering refrigerant, it is important not to mix different refrigerants in the same container because the mixture is typically

impossible to reclaim. Only one type of refrigerant can be recovered into any one storage cylinder. Reusable containers for refrigerants that are under high pressure (above 15 psi) and at normal ambient temperature must be hydrostatically tested and date-stamped every five years.

Refrigerant recovery containers are the only containers designated as "refillable" by the Department of Transportation (DOT) and that can be used for refrigerant recovery. Refillable containers must be hydrostatically tested and date stamped every five years.

▶ Technical Fact

REUSABLE CONTAINER FILL LEVEL

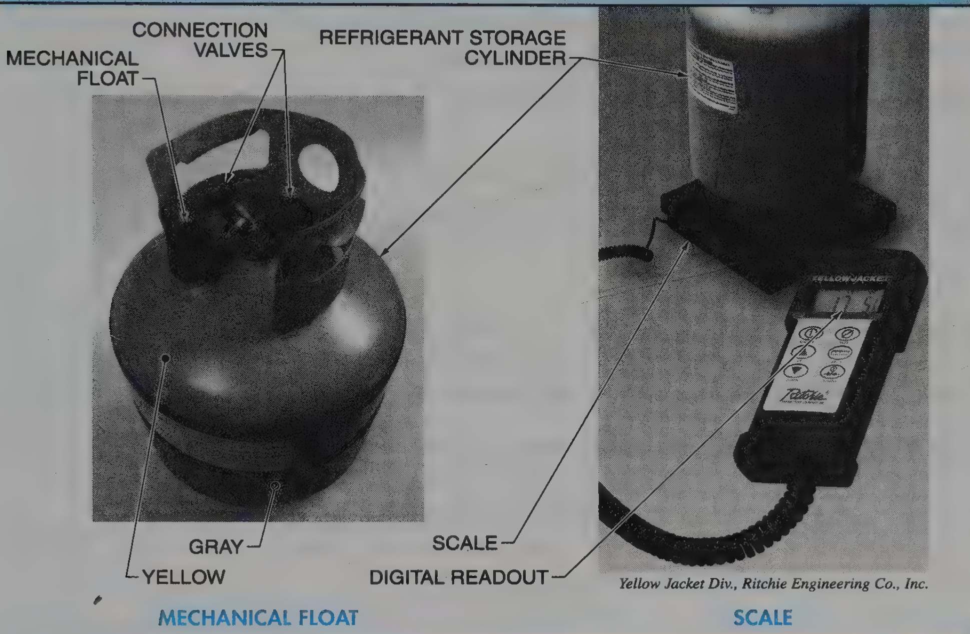


Figure 6-10. To ensure 80% capacity when transferring refrigerant to an empty or pressurized cylinder, the safe filling level is controlled by a mechanical float device, by weighing the cylinder using a scale, or electronic shutoff devices.

DEPARTMENT OF TRANSPORTATION CLASSIFICATION TAG

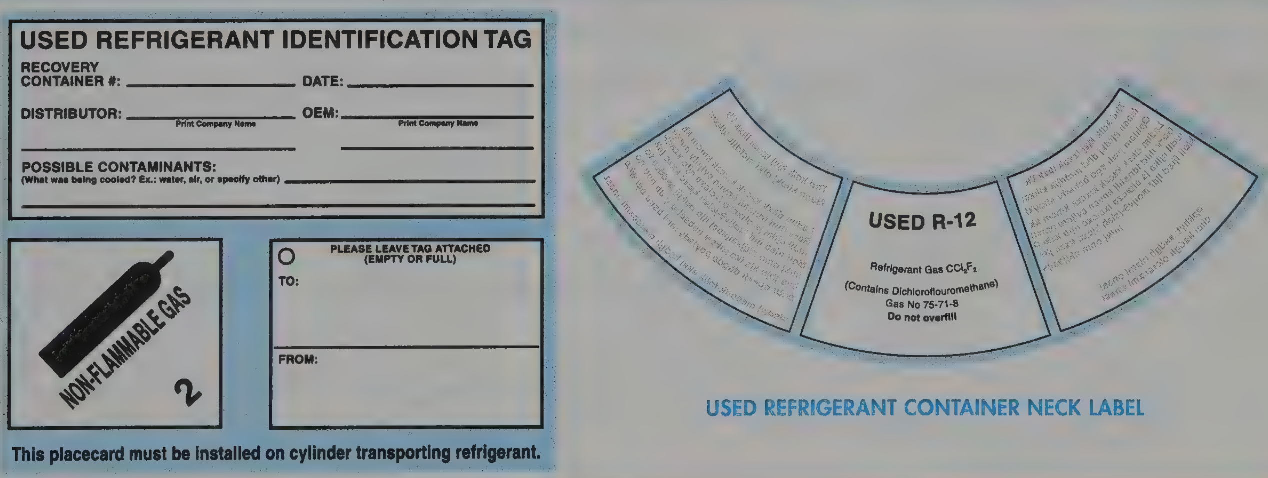


Figure 6-11. When transporting cylinders containing used refrigerant, the Department of Transportation (DOT) requires that DOT classification tags be attached to containers.

Discussion Questions

1. Why is the cost of service work on air conditioning and refrigeration systems increasing?
2. Why are CFC refrigerants becoming too expensive to use?
3. Why are refrigerants recovered?
4. What are the two types of refrigerant recovery methods used to recover refrigerant?
5. How are refrigerants recycled?
6. Why are refrigerants reclaimed?
7. How are refrigerant reclaiming companies certified?
8. How does a low-loss fitting function when recovering refrigerants?
9. What do the EPA established efficiency standards require?
10. How can refrigerant recovery equipment be grandfathered?
11. How are refrigerant containers properly disposed?
12. What is the difference between a disposable container and a reusable container?
13. How must refrigerant containers be labeled for transport according to the Department of Transportation?

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REVIEW QUESTIONS

Name ______________________________ Date ______________

______ **1.** The EPA has eliminated the production of Class I substances and the EPA also wants the substances ___.

A. contained
B. reclaimed
C. destroyed
D. recycled

______ **2.** As CFC refrigerants become harder to obtain, CFC refrigerants will become too ___ to use.

A. involved in paperwork
B. contaminated
C. old
D. expensive

______ **3.** Refrigerants must be recovered during the servicing of refrigeration systems that contain ___ refrigerants.

A. Class I
B. Class III
C. perfluorocarbon
D. universal

______ **4.** ___ is when the recovery process is achieved with the assistance of system components in removing refrigerant from a system.

A. On-site reclamation
B. Recovery reclamation
C. Passive recovery
D. Active recovery

______ **5.** Recycled refrigerant is not required to be ___.

A. used by the same owner
B. tested for quality
C. recovered by a certified technician
D. cleaned of moisture and acids

______ **6.** ___ refrigerant is necessary when refrigerant is heavily contaminated or the quality is unknown.

A. Reclaiming
B. Recovering
C. Recycling
D. Destroying

______ **7.** Refrigerant mixtures are impossible to ___.

A. reclaim
B. recover
C. recycle
D. destroy

_______________ **8.** Refrigerant reclaimers are required to return refrigerants to the purity level specified in the ___.

A. Montreal Protocol
B. Clean Air Act—Section 608
C. ARI Standard 700-1999
D. EPA Standard 40 CPR Part 82

_______________ **9.** When refrigerant changes ownership, the refrigerant must be ___.

A. recycled
B. reclaimed
C. an HFC refrigerant
D. a PFC refrigerant

_______________ **10.** ___ automatically trap refrigerant in hoses when disconnected and are required on all recovery, recycling, and reclaiming equipment.

A. Filters
B. Manual valves
C. Gauge sets
D. Low-loss fittings

_______________ **11.** The EPA requires that recovery equipment manufactured on or after ___ be tested by an EPA-approved testing organization.

A. September 16, 1987
B. May 1, 1990
C. June 29, 1990
D. November 15, 1993

_______________ **12.** All recovery equipment now manufactured must have a ___ on the equipment.

A. recovery container
B. scale
C. certification label or stamp
D. four-valve gauge manifold

_______________ **13.** ___ are color-coded according to the type of new refrigerant in the container.

A. Disposable containers
B. Reusable containers
C. 20 lb refrigerant cylinders
D. Refrigerant cylinders larger than 20 lb

_______________ **14.** Refrigerant storage cylinders can be filled to a maximum of ___% capacity.

A. 70
B. 80
C. 90
D. 100

_______________ **15.** Reusable refrigerant containers must be hydrostatically tested and date-stamped every ___ years.

A. 1
B. 2
C. 5
D. 10

7 Service Practices

Technicians who leak test, recover, evacuate, and charge systems must use service practices dictated by EPA regulations. Service practices that comply with EPA regulations minimize the amount of refrigerant that escapes into the atmosphere. The service practices must also create a safe work environment for technicians and not damage equipment.

TOOLS AND EQUIPMENT

Tools and equipment are required for servicing an air conditioning or refrigeration system. To troubleshoot and service air conditioning and refrigeration systems, an understanding of tool capabilities is required along with system-specific service procedures.

Vacuum pump efficiency depends on the number of pump stages and the purity of the vacuum pump oil.

Technical Fact

Vacuum Pumps

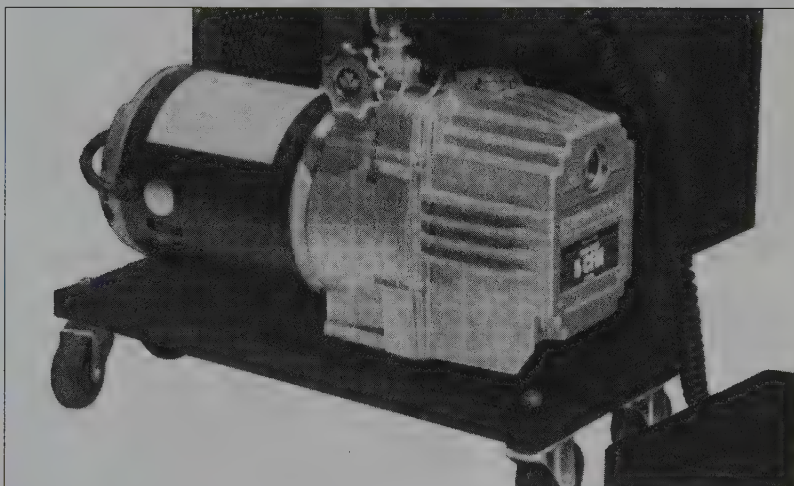
A *vacuum pump* is a device used to create pressures below atmospheric pressure (vacuum in in. Hg) in a closed system. Vacuum pumps remove air, noncondensable gases, and moisture from systems before charging the system. *Evacuation* is the process of removing air and moisture from air conditioning or refrigeration systems. See Figure 7-1.

Air and noncondensable gases take up space and raise the operating pressures of a system. Air can also contain moisture that damages equipment and causes the formation of hydrofluoric and hydrochloric acids in a system.

A list of good practices for conserving refrigerant includes:

- *Recovering/recycling refrigerants*
- *Keeping systems tight*
- *Finding and repairing leaks*

Technical Fact



Mastercool® Inc.

Vacuum pumps are used to evacuate air conditioning and refrigeration systems.

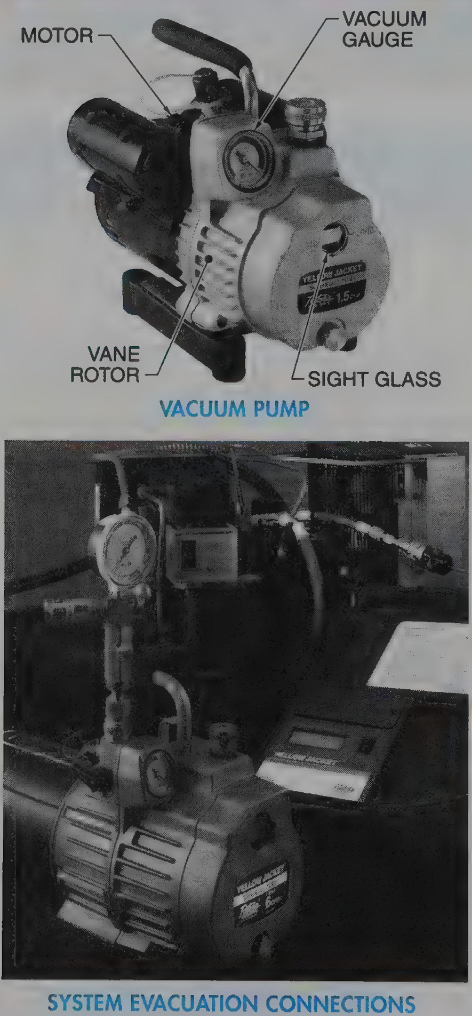
Low-vacuum vacuum pumps are used for 0 psi to 15 in. Hg vacuum. Medium-vacuum pumps are used for applications up to 26 in. Hg vacuum. High-vacuum pumps are used for applications up to 29.19 in. Hg (50 microns) vacuum.

▶ Technical Fact

Final system vacuum or system vacuum levels are always measured with the vacuum pump OFF and isolated from the system.

▶ Technical Fact

VACUUM PUMPS



Yellow Jacket Div.
Ritchie Engineering Co., Inc.

Figure 7-1. Vacuum pumps create pressures less than atmospheric pressure (14.696 psia or 0 psi).

The piping connections to the vacuum pump must be as short in length and as large in diameter as possible.

▶ Technical Fact

Gauge Manifolds

A *gauge manifold* is a device that has two gauges, a manifold with valves, and connecting hoses to control refrigerant transfer. A gauge manifold is an important tool used when servicing air conditioning or refrigeration systems. A gauge manifold may have two valves or four valves, depending on whether the manifold has separate valves for vacuum, low-pressure, high-pressure, and refrigerant cylinder or recovery machine connections. **See Figure 7-2.** Gauges are used when charging a system with refrigerant or evacuating a system. The low-pressure (compound) gauge and connecting hose are typically blue in color. The low-pressure gauge provides pressure readings above (psi) and below (0 in. Hg) atmospheric pressure. The high-pressure gauge and connecting hose are typically color coded red. The high-pressure gauge provides pressure readings from 0 psi to 500 psi. The center port on a three port gauge manifold is used during the recovery, evacuation, and charging processes. A yellow hose is typically used with the center port.

Gauge manifolds connect the low-pressure hose (blue) to a suction line access port. The high-pressure hose (red) connects to a liquid line access port. The center hose (yellow) connects to the vacuum pump or recovery unit.

▶ Technical Fact

Leak Detectors

A *leak detector* is a device that is used to detect refrigerant leaks in a pressurized air conditioning or refrigeration system. Leak detectors available include electronic, fluorescent, ultrasonic, fixed, or halide torch detectors. **See Figure 7-3.**

An *electronic leak detector* is a leak detector that detects the presence of halogen gas. Hand-held electronic leak detectors are considered the industry standard for detecting the location of refrigerant leaks. A *fluorescent leak detector* is a leak detector that uses a UV light to detect fluorescent

dye that was added to a system. An *ultrasonic leak detector* is a leak detector that senses the sounds created by a leak. A *fixed leak detector* is a stationary leak detector system with sensors and controllers to detect one specific type of refrigerant. A *halide torch leak detector* is a leak detector that uses a torch flame that changes color depending on which refrigerant is exposed to the copper element. Halide torch leak detectors are the least common type of leak detector used because of safety concerns created by the open flame. Nitrogen can also be used to pressurize a system (nitrogen with a trace of R-22) to determine if there are any leaks in the system. Nitrogen must not be added to a fully charged system and released to the atmosphere. A technician must always verify the maximum test pressure allowed in a system by checking the pressure rating on the nameplate of the equipment. Soap bubbles are also used to pinpoint leaks in a system by covering the piping with a soapy solution. As the refrigerant leaks, bubbles are formed at the point of the leak. Electronic and ultrasonic leak detectors detect the general area of a small refrigerant leak.

Technicians must not use oxygen or compressed air to pressurize or leak check a system. Oxygen or compressed air mixed with oil is very explosive.

▶ Technical Fact

The water immersion method of leak detection requires that refrigerant be recovered and that the system be pressurized with dry nitrogen. The entire system or sealed component is submerged in water to indicate leaking parts.

▶ Technical Fact

Systems that are typically refrigerant charged must be checked with pressurized nitrogen when the system is empty. Dry nitrogen causes the least amount of damage to the environment.

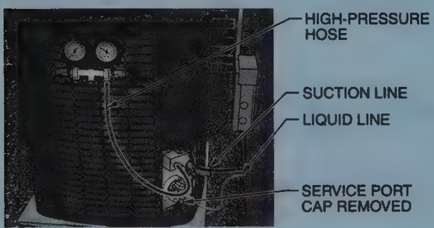
▶ Technical Fact

When corrosion buildup is found within the body of a relief valve, the valve must be replaced.

▶ Technical Fact

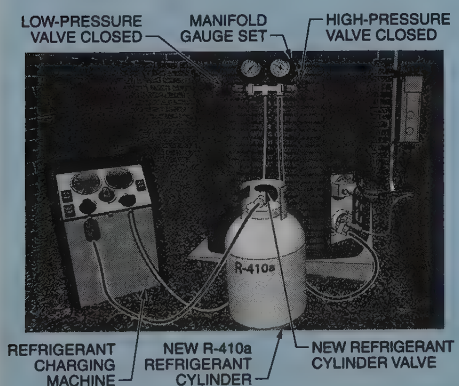
Leak Testing with Electronic Leak Detectors Procedure

1. Connect high-pressure hose of manifold gauge set to suction valve service port.

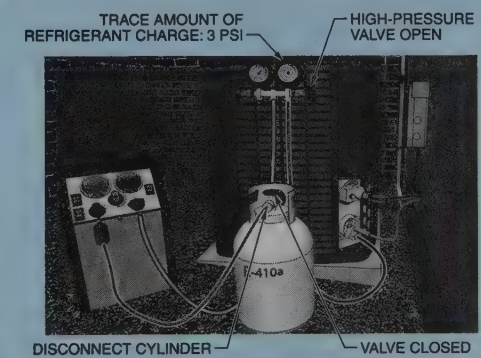


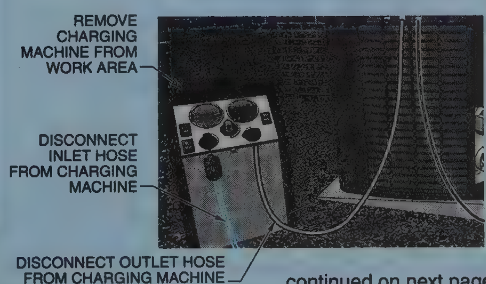
Note: Typically high-pressure hose is connected to liquid line port; however, connecting it to suction port helps to protect manifold gauge set from damage caused by high pressures.

2. With both manifold valves closed, connect cylinder of R-410a refrigerant to charging machine.
   a. Connect charging machine to manifold gauge set.
   b. Open valve on R-410a cylinder (vapor only).



3. Open high-pressure side of manifold to allow R-410a into line set and evaporator coil. Weigh in trace amount of R-410a (maximum of 2 oz of refrigerant or 3 psi of pressure).
4. Close valve on R-410a cylinder and valve on high-pressure side of manifold gauge set.
5. Disconnect charging machine from manifold gauge set and remove inlet hose.
   a. Disconnect R-410a cylinder.





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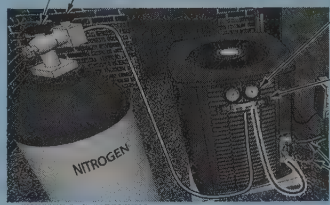
Leak Testing with Electronic Leak Detectors Procedure *(continued)*

6. Connect cylinder of dry nitrogen with pressure regulating valve to center port of manifold gauge set.

Note: When using high-pressure gas such as nitrogen for pressure purposes, be sure to use regulator that can control pressure down to 1 psi or 2 psi.

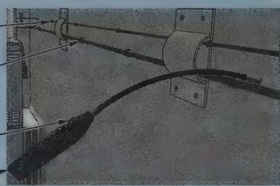
7. Open dry nitrogen cylinder valve. Adjust nitrogen pressure to 150 psi. Open valve on high-pressure side of manifold gauge set to pressurize line set and evaporator coil.



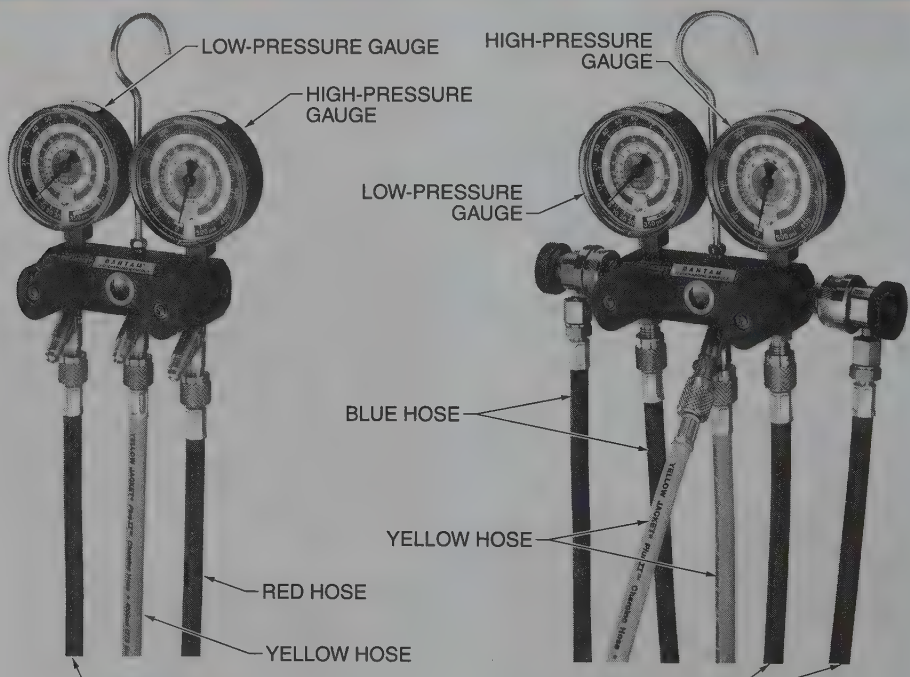
8. Check all joints for leaks.

   a. After short period of time, open refrigerant port to ensure that an adequate amount of refrigerant has been added for detection (refrigerant requirements will vary with piping lengths).

9. Purge dry nitrogen and R-410a mixture. Correct any leaks and recheck.



GAUGE MANIFOLDS



Yellow Jacket Div., Ritchie Engineering Co., Inc.

Figure 7-2. Four-valve gauge manifolds have separate valves for vacuum, low-pressure, high-pressure, and refrigerant or recovery machine connections.

REFRIGERATION LEAK DETECTORS

SPX Robinair

ELECTRONIC

Yellow Jacket Div.
Ritchie Engineering Co., Inc.

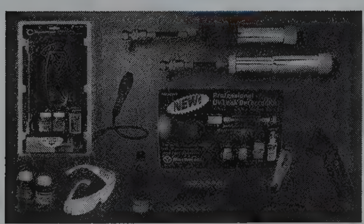
UV FLUORESCENT

SPX Robinair

ULTRASONIC

Inficon

FIXED



Mastercool® Inc.

LEAK DETECTION KIT

Figure 7-3. A leak detector is a device that is used to detect refrigerant leaks in air conditioning or refrigeration systems.

Leak Detection Methods. Soap bubbles are used as a safe way to detect leaks from a system in a hazardous environment. Soap bubbles can only be used if the system being checked is fully pressurized. Electronic leak detectors work well for detecting small leaks, but large leaks can cause false positives. UV Fluorescent leak detection works well as long as the system can be run after the dye has been injected into the system.

Ultrasonic and electronic leak detectors can find the general area of small leaks. Halide torch leak detectors can determine what refrigerant is leaking and how much. Halide torch leak detectors cannot be used in many applications because of hazardous conditions created by the open flame. Standing pressure and standing vacuum are used to determine if a leak exists and possibly the size of the leak. Neither standing pressure nor standing vacuum can be used to determine the location of a leak.

The low-side test-pressure data-plate value is the maximum pressure allowed for leak testing a system.

▶ Technical Fact

Refrigerant Recovery Machines

All refrigerants must be recovered before opening or disposing of any type of appliance. Recovery equipment typically has desiccant packages to trap moisture, and an in-line particulate filter (15 micron size) to trap solids. Long hoses between the air conditioning or refrigeration unit and the recovery machine must be avoided to avoid excessive pressure drops. Long hoses also cause an increase in the recovery time and an increase in refrigerant emissions if refrigerants escape to the atmosphere, because a longer hose has more volume. **See Figure 7-4.** To facilitate refrigerant recovery, the EPA requires that service apertures or process stubs be installed on all appliances containing Class I and Class II refrigerants.

To verify the allowable recovery-machine test pressure, check the design pressure on the equipment nameplate.

▶ Technical Fact

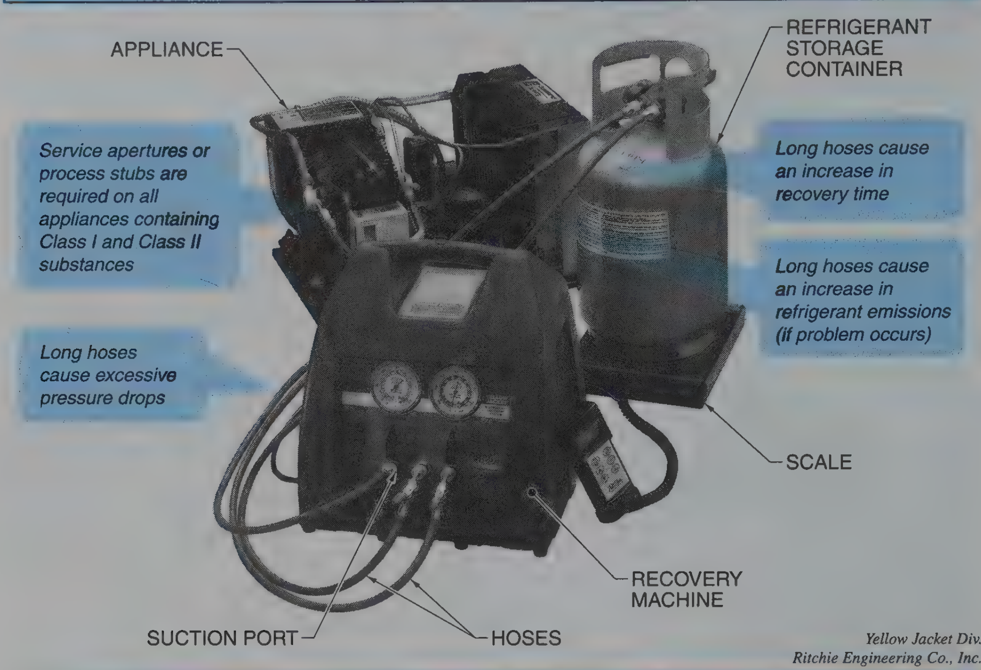
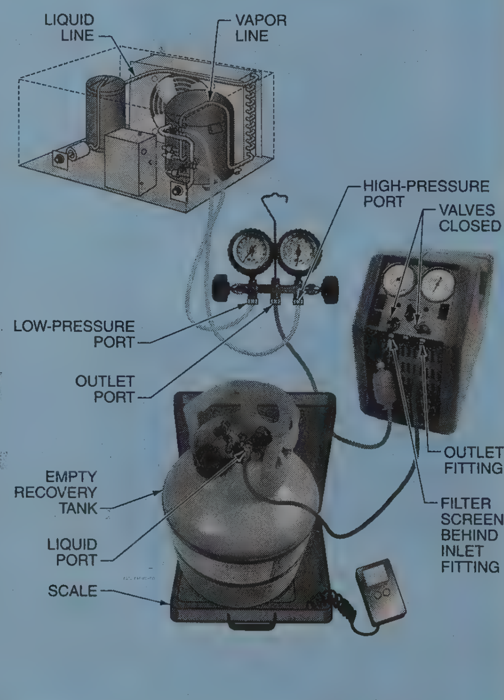


Figure 7-4. Long hoses cause an increase in the recovery time and can also cause an increase in refrigerant emissions if refrigerants are escaping to the atmosphere.

Recovering Refrigerant — Type I Systems Procedure

1. Set up recovery equipment to recover refrigerant from the Type I system.
   a. Verify that the clean filter screen is installed behind the inlet fitting.
   b. Connect a hose from the outlet fitting of the recovery unit to the liquid port on the recovery cylinder.
   c. Connect a hose from the inlet fitting on the recovery unit to the output port on the manifold gauge set.
   d. Connect a hose from the liquid (low-pressure) side of the manifold gauge set to the liquid side of the system.
   e. Connect a hose from the vapor (high-pressure) side of the manifold gauge set to the vapor side of the system.
   f. Verify that the inlet and outlet valves on the recovery unit are closed.
   g. Place the recovery cylinder on a scale to avoid overfilling the cylinder.



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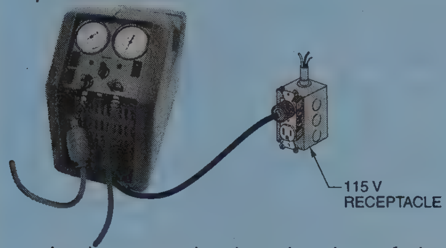
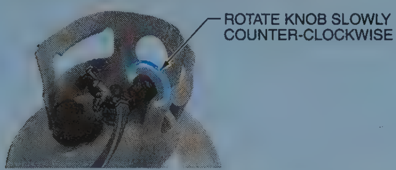
Recovering Refrigerant — Type I Systems Procedure *(continued)*

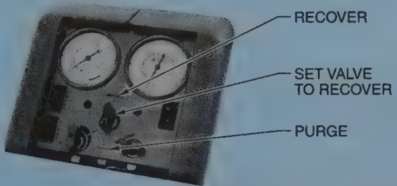
2. Plug the recovery unit into a 115 V power source.



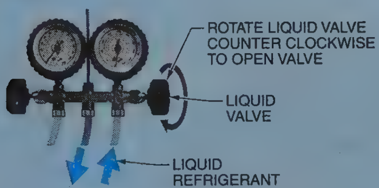
3. Slowly open the liquid valve of the recovery cylinder while watching the hoses and connections for leaks.



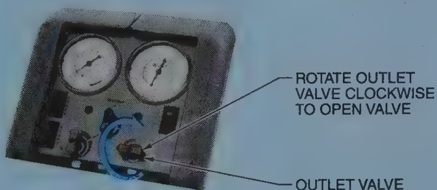
4. Set the recovery/purge valve on the recovery unit to RECOVER.



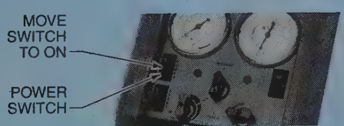
5. Open the liquid valve on the manifold gauge set. *Note:* Opening the liquid valve removes liquid refrigerant from the system first, greatly reducing recovery time.



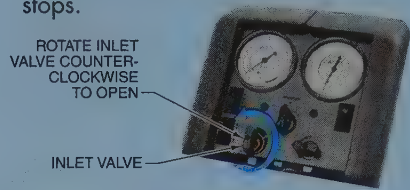
6. Open the outlet valve on the recovery unit.



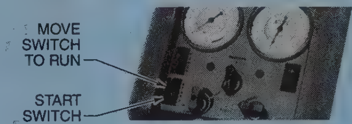
7. Toggle the power switch to the ON position.



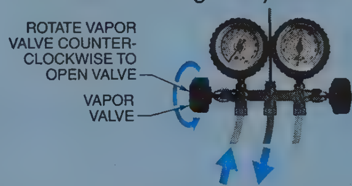
8. Slowly open the inlet valve on the recovery unit. Note: If the recovery unit begins to "knock," slowly throttle back (close) the inlet valve until the noise stops.



9. Toggle the start switch to RUN.

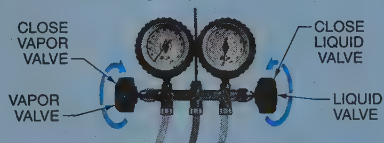


10. Once the liquid refrigerant has been removed from the system, open the vapor valve on the manifold gauge set to finish evacuating the system.

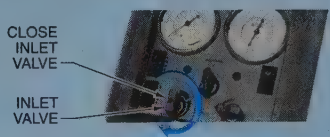


11. Run the recovery unit until the desired vacuum (typically 10 in. Hg vacuum for small Type I systems) is achieved.

12. Close the vapor and liquid valves on the manifold gauge set.



13. Rotate the inlet valve on the recovery unit to the closed position.



14. Toggle the start switch to the standby position and the power switch to the OFF position.

15. Always purge the recovery unit and hoses after a recovery procedure.

EPA EVACUATION REQUIREMENTS

Since July 13, 1993, technicians have been required to evacuate air conditioning and refrigeration equipment to established vacuum levels when opening equipment. Recovery and recycling equipment must be certified by an EPA-approved equipment testing organization. Persons who add refrigerant to an appliance to top off the system are not required to evacuate the system.

EXCEPTIONS TO EVACUATION REQUIREMENTS

The EPA has established limited exceptions to evacuation requirements for repairs to leaky equipment and for repairs of equipment that are not considered major. Some system repairs such as replacing a condenser fan motor are not required to be followed by an evacuation of the equipment.

If, due to leaks, evacuation to the levels indicated on system evacuation tables is not attainable, or if the evacuation would substantially contaminate the refrigerant being recovered, the person opening an appliance must:

- isolate leaking from nonleaking components wherever possible. **See Figure 7-5.**
- evacuate nonleaking components to the levels found in the evacuation table
- evacuate leaking components to the lowest level that can be attained without substantially contaminating the refrigerant (the evacuation level of leaking systems cannot exceed 0 psi).

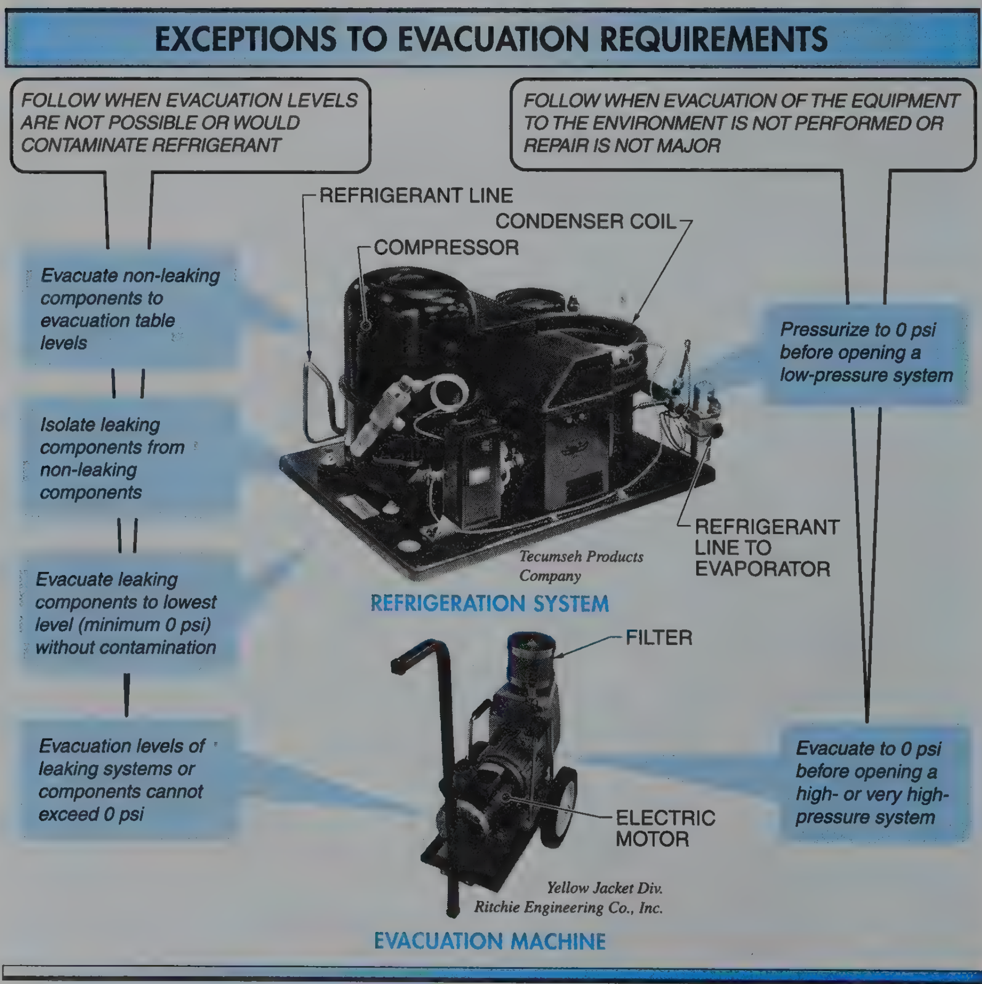
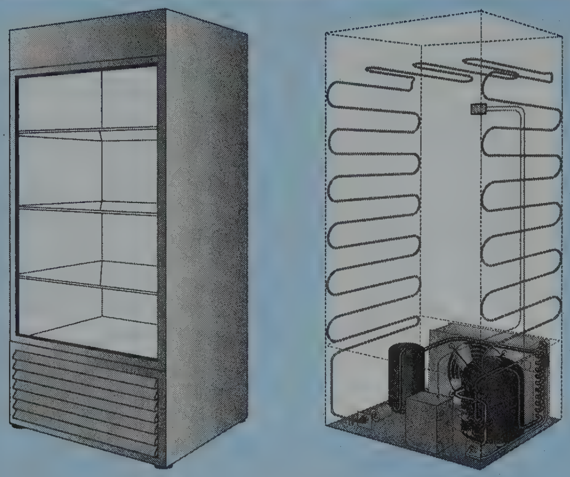


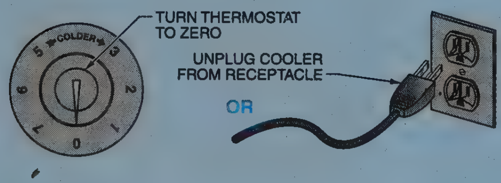
Figure 7-5. Exceptions to system evacuation requirements occur when a system has leaky components or if a minor repair is required.

Evacuating Type I Systems Procedure

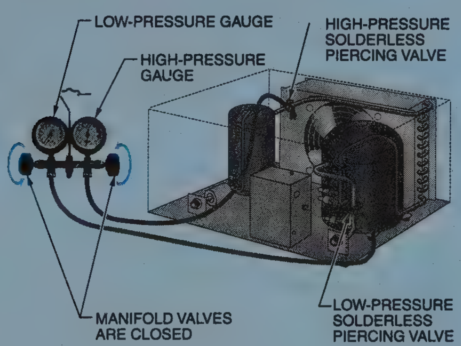


TYPE I SYSTEM (COOLER)

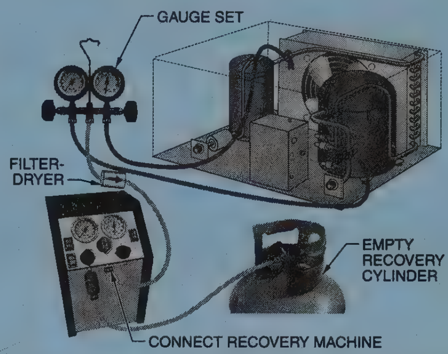
1. Shut off the Type I refrigeration system. Stop the compressor.



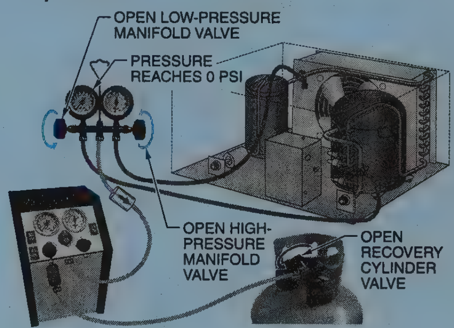
2. Install solderless service piercing valves and connect gauge set.
   a. Connect the high-pressure (red) gauge to the high-pressure liquid service valve and the low-pressure (blue) gauge to the low-pressure vapor service valve.
   b. Ensure that the valves on the gauge set are in the closed position.



3. Connect a recovery machine to the center manifold (yellow) hose of the gauge set.
   a. The recovery machine should have a drier, so moisture can be removed from the evacuated refrigerant.
   b. A recovery cylinder is required to store evacuated refrigerant.

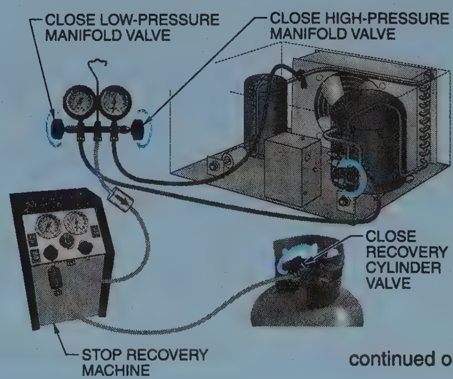


4. Open the low-pressure valve and the high-pressure valve on the gauge set, and valve on the recovery cylinder.



5. Operate the recovery machine to draw the refrigerant out of the refrigeration system.

6. Continue operating the recovery machine until the pressure in the system reaches 0 psi. Then, stop the vacuum pump and close the low-pressure valve on the manifold.



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Evacuating Type I Systems Procedure *(continued)*

7. Observe the gauges for a pressure rise.
   - If pressure rises quickly (to atmospheric pressure), the hose connections could be loose. Tighten the connections, repeat steps 4 through 6, and observe.
   - If pressure continues to rise quickly, there is a leak in the system. Open the low-pressure valve and resume evacuating.
   - If pressure rises slowly, there is moisture in the system or refrigerant still in the system. Open the low-pressure valve and resume evacuating.
8. Hold system pressure at 0 psi for a few hours or half a day, depending on the size of the refrigeration system.
9. Close the low-pressure service valve and the recovery cylinder valve. Remove the gauge set from the system and recovery cylinder.
10. Perform necessary repairs or replace parts.
11. Perform a leak test once repairs have been made.
12. Evacuate the refrigeration system once again. Start with step 2 and continue to step 9.
13. Recharge the system using the evacuated refrigerant or new refrigerant.

If evacuation of the equipment to the environment is not to be performed when repairs are complete, the appliance must be:

- evacuated to at least 0 psi before the appliance is opened if the appliance is a high- or very high-pressure system
- pressurized to 0 psi before the appliance is opened if the appliance is low-pressure.

Methods that require subsequent purging with nitrogen cannot be used except with appliances containing R-113 refrigerant.

The moisture of the atmosphere on a very dry day (15% humidity) is about 1000 ppm. In a refrigeration system, moisture content of 100 ppm is high and must be removed prior to charging the system.

Technical Fact

Dehydration and Evacuation

Dehydration is the process of removing moisture (water vapor) from air conditioning or refrigeration systems. As air enters a system, moisture also enters. Moisture in an air conditioning or refrigeration system will cause acids to form. Dehydration of a system is accomplished by evacuating the system. A system is dehydrated when a vacuum gauge shows that the desired deep vacuum has been reached and held. Systems are typically evacuated at the conclusion of system service to eliminate noncondensables such as air from the system.

To acquire an accurate vacuum reading during the evacuation process, the vacuum gauge must be located in the system as far from the vacuum pump as possible. Vacuum lines (hoses) must be equal to or larger in size than the pump intake connection. Vacuum is typically measured in inches of mercury (in. Hg). Deep vacuums are typically measured using microns. An evacuation to 500 microns is sufficient for most systems. A system can never be overevacuated. **See Figure 7-6.** Factors that affect the evacuation time of a system include the following:

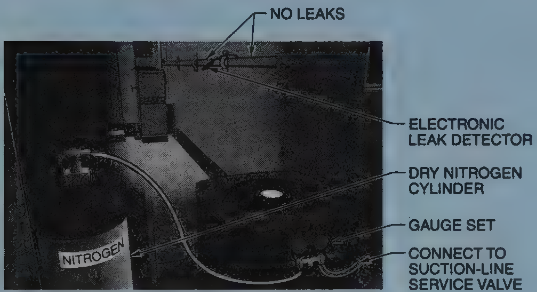
- size of equipment being evacuated
- ambient temperature
- amount of moisture in the system
- size (capacity) of the vacuum pump
- length and diameter of hoses
- whether the recovery vessel is packed in ice

Dehydration is accomplished by lowering system pressure. As system pressure drops, the boiling point of the moisture is reached, causing the moisture to vaporize and be pulled out of the system. The use of a properly sized vacuum pump for an application is very important. A vacuum pump that is too small cannot create enough vacuum and will not properly dehydrate a system. A vacuum pump that is too large creates a deep vacuum too quickly and will cause moisture in the system to freeze.

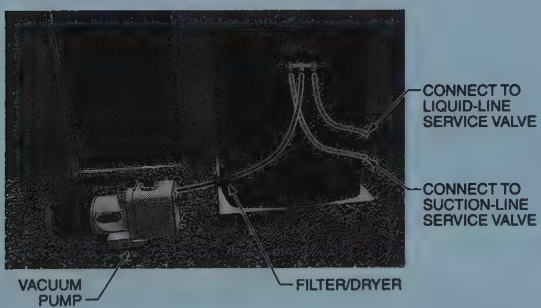
Vacuum pumps are used to remove moisture (dehydration) from air conditioning systems.

Removing Moisture from Systems Procedure

1. Use dry nitrogen to pressurize system and check for leaks. Repair leaks, if possible.



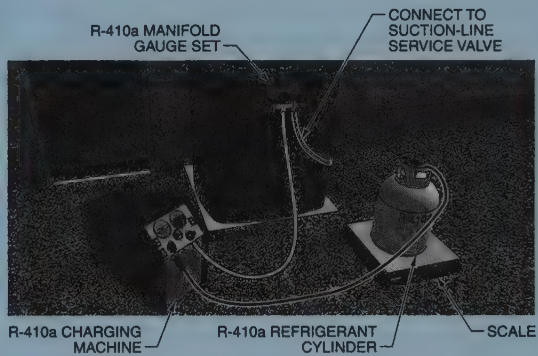
2. Evacuate system to remove as much moisture as possible.



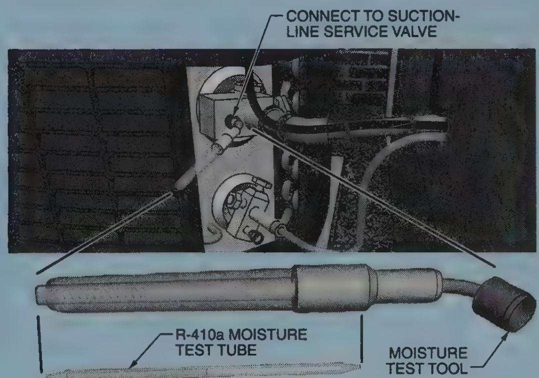
3. Use dry nitrogen to break the vacuum.

4. Evacuate system again.

5. Charge by weight appropriate amount of R-410a refrigerant (listed on unit nameplate) into system.



6. Monitor system to determine amount of moisture remaining in the oil. Use test kit to verify that moisture content is within dry color range of kit.



FACTORS AFFECTING SYSTEM EVACUATION TIME

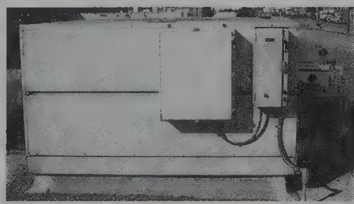
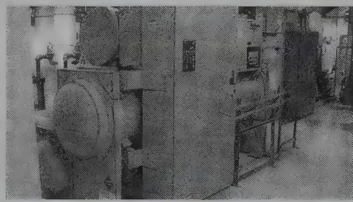
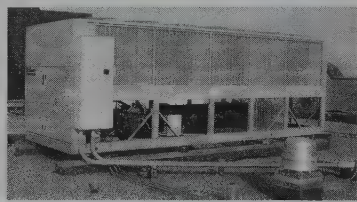
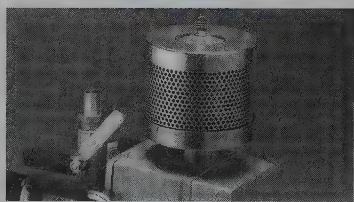
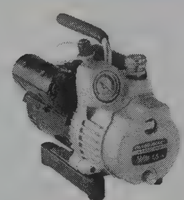
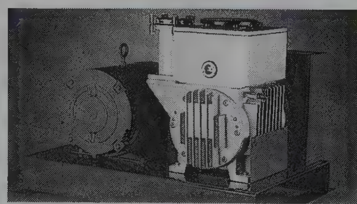
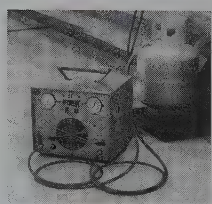
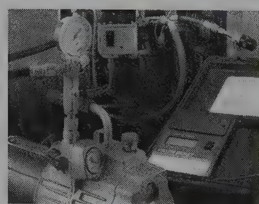
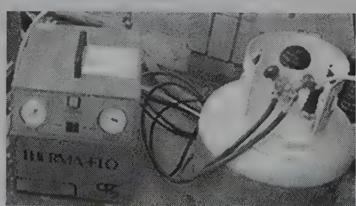
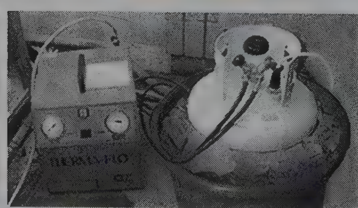
Evacuation Speed Factors	Slower Evacuation Speed	Faster Evacuation Speed
Size of equipment	 LARGE VOLUME	 *Carrier Corporation* SMALL VOLUME
Ambient temperature	 *McQuay International* BASEMENT	 *McQuay International* ROOF
Moisture in system	 *Ritchie Engineering Co., Inc.* LARGE VOLUME	 *Ritchie Engineering Co., Inc.* SMALL VOLUME
Size of vacuum pump	 *Ritchie Engineering Co., Inc.* SMALL CFM	 *Ritchie Engineering Co., Inc.* LARGE CFM
Length and diameter of hoses	 *Ritchie Engineering Co., Inc.* LONG HOSES	 *Ritchie Engineering Co., Inc.* SHORT HOSES
Recovery vessel packed in ice	 *ATOFINA Chemical Co.* WITHOUT ICE	 *ATOFINA Chemical Co.* WITH ICE

Figure 7-6. Many factors affect the time required to evacuate a system.

During system dehydration, the temperature of the system should not be lower than 50°F because lower temperatures would require a higher than normal vacuum (held for 15 min) to remove the moisture.

▶ Technical Fact

Recovery and Recycling Machines

Recovery and recycling machines manufactured today typically have the ability to recover more than one type of refrigerant. The machines can then be used on various systems or if a technician discovers that a system filled with R-22 refrigerant had R-502 refrigerant added. Refrigerants that have been mixed must be recovered into a separate tank as waste for disposal. When a technician is unsure of the quality of recycled refrigerant, a sample should be taken for analysis by a laboratory or in-house analysis machine. **See Figure 7-7.**

Upon completion of refrigerant transfer between the air conditioning or refrigeration system and the recovery unit, the technician must guard against trapping liquid refrigerant in the system compressor (between service valves).

REFRIGERANT SAMPLING

Figure 7-7. When a technician is unsure of the quality of recycled refrigerant, a sample should be taken for analysis by a laboratory or in-house analysis machine.

PRESSURE-TEMPERATURE RELATIONSHIPS

At atmospheric pressure water boils at 212°F. Atmospheric pressure is 0 psi or 14.696 psia. To boil water at a temperature less than 212°F, the pressure on the water must be decreased. To raise the boiling point temperature of water, the pressure on the water must be increased. Water that boils at 212°F at atmospheric pressure boils at 40°F at 29.67 in. Hg vacuum or 0.12 psia. **See Figure 7-8.**

Refrigerant analysis must be performed as part of routine maintenance or after a compressor motor burnout. Refrigerant temperature and point of sampling are critical for proper analysis.

▶ Technical Fact

Pressure-Temperature Charts

A *pressure-temperature (P-T) chart* is a reference tool used to determine the pressure of a refrigerant at a given temperature or to determine the temperature of a refrigerant at a given pressure. The boiling point or condensing point of a refrigerant is known as the saturation point. A P-T chart is a chart that shows corresponding saturation temperature for a given pressure of a specified refrigerant.

All points on a P-T chart are saturation points. P-T charts are used by the HVAC industry to determine temperatures or pressures of refrigerants at specific times of system operation. To determine the boiling point of a refrigerant at atmospheric pressure, the corresponding temperature at 0 psi must be found. To determine the pressure corresponding to the freezing point of water, the pressure corresponding to 32°F on a P-T chart is found. **See Figure 7-9.**

The proper charging method for blended refrigerants is to add the refrigerant into the high-pressure side of the system as a liquid by weight.

▶ Technical Fact

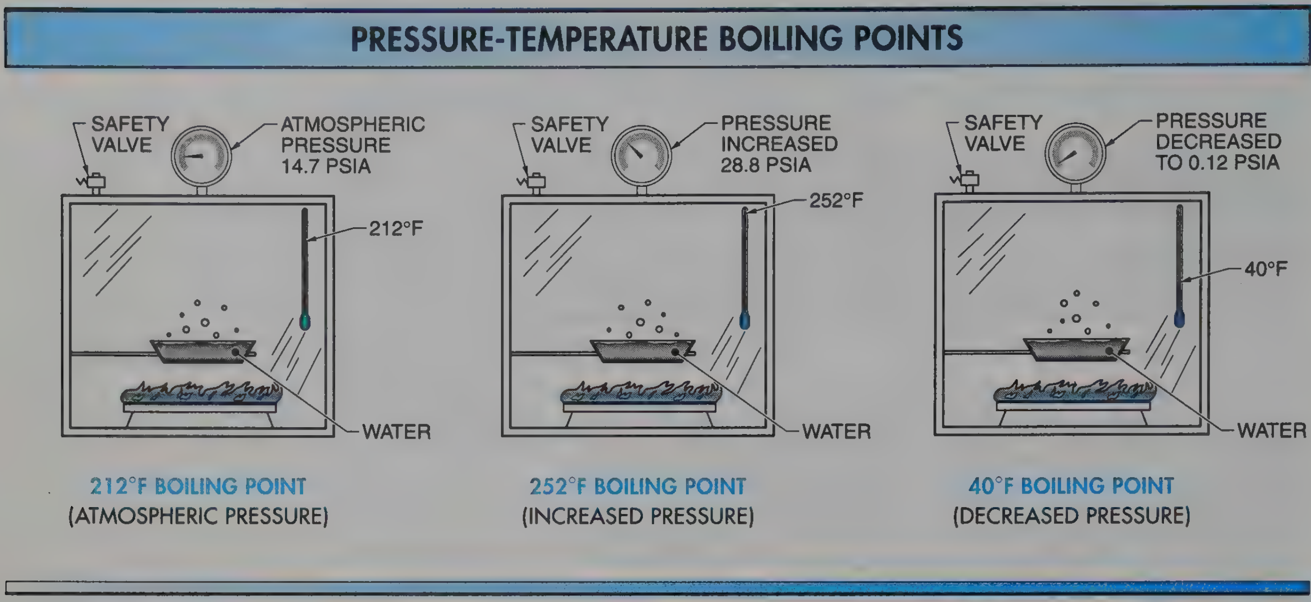


Figure 7-8. To lower the boiling point of water, the pressure on the water must be decreased, and to raise the boiling point of water, the pressure on the water must be increased.

PRESSURE-TEMPERATURE CHART

Temp*	R-11†	R-12†	R-22†	R-113†	R-114†	R-500†	R-502†	R-134a†	R-123†
–50°	28.9‡	15.4‡	6.2‡		27.1‡		0.0	18.7‡	
–45°	28.7‡	13.3‡	2.7‡		26.6‡		1.9	16.9‡	
–40°	28.4‡	11.0‡	0.5		26.0‡	7.6‡	4.1	14.8‡	
–35°	28.1‡	8.4‡	2.6		25.4‡	4.6‡	6.5	12.5‡	
–30°	27.8‡	5.5‡	4.9	29.3‡	24.6‡	1.2‡	9.2	9.5‡	
–25°	27.4‡	2.3‡	7.4	29.2‡	23.8‡	1.2	12.1	6.9‡	
–20°	27.0‡	0.6	10.1	29.1‡	22.9‡	3.2	15.3	3.7‡	27.8‡
–15°	26.5‡	2.4	13.2	26.9‡	21.9‡	5.4	18.8	0.6	27.4‡
–10°	26.0‡	4.5	16.5	28.7‡	20.5‡	7.8	22.6	1.9	26.9‡
–5°	25.4‡	6.7	20.1	28.5‡	19.3‡	10.4	26.7	4.0	26.4‡
0°	24.7‡	9.2	24.0	28.2‡	17.8‡	13.3	31.1	6.5	25.9‡
5°	23.9‡	11.8	28.2	27.9‡	16.2‡	16.4	35.9	9.1	25.2‡
10°	23.1‡	14.5	32.8	27.6‡	14.4‡	19.7	41.0	11.9	24.5‡
15°	22.1‡	17.7	37.7	27.2‡	12.4‡	23.4	46.5	15.0	23.8‡
20°	21.1‡	21.0	43.0	26.8‡	10.2‡	27.3	52.4	18.4	22.8‡
25°	19.9‡	24.5	48.8	26.3‡	7.8‡	31.5	58.8	22.1	21.8‡
30°	18.6‡	28.5	54.9	25.8‡	5.2‡	36.0	65.6	26.1	20.7‡
35°	17.2‡	32.6	31.5	25.2‡	2.3‡	40.9	72.8	30.4	19.5‡
40°	15.5‡	37.0	68.5	25.5‡	0.4	46.1	80.5	34.1	18.1‡
50°	13.9‡	41.7	76.0	25.8‡	2.0	51.4	88.7	40.1	16.6‡

* in degrees Fahrenheit
† in psi
‡ in inches of mercury

Figure 7-9. To determine the boiling point of a refrigerant, the temperature of the refrigerant must be found that corresponds to 0 psi.

CHANGING REFRIGERANT OIL

The oil in a refrigeration appliance may contain large amounts of dissolved refrigerant. The EPA requires a reduction in the pressure prior to an oil change to ensure that the bulk of the refrigerant contained in the oil is recovered. Pressure must be reduced to a maximum of 5 psi. There are two acceptable procedures for the recovery of refrigerant containing oil:

- Evacuate (or pressurize) the refrigeration appliance, or isolated portion, to a pressure no greater than 5 psi and then remove the oil.
- Drain the oil into a system receiver to be evacuated (or pressurized) to a pressure no greater than 5 psi.

These procedures minimize the loss of refrigerant from the oil and the interior of the refrigeration appliance while the oil is being drained. It is a violation to change oil at a pressure higher than 5 psi.

Discussion Questions

1. Why are air conditioning and refrigeration systems evacuated?
2. How are hydrofluoric and hydrochloric acids formed in air conditioning and refrigeration systems?
3. How is a low-pressure compound gauge different from a high-pressure gauge?
4. Why are soap bubbles used for leak detection?
5. Why should long hoses be avoided on recovery machines?
6. How does the EPA keep control of what recovery and recycling equipment is used during system servicing?
7. How is a high- or very high-pressure system handled when the system will not be evacuated to the environment at the end of a minor repair?
8. Why is a system dehydrated?
9. What affects the time it takes to evacuate a system?
10. How is a pressure-temperature chart useful to a technician?

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Access Code: 827160

REVIEW QUESTIONS

Name ______________________________ Date ______________

_______________ **1.** A ___ is a device used to create pressures below atmospheric pressure (in in. Hg).
- A. vacuum pump
- B. gauge manifold
- C. noncondensable
- D. halide torch

_______________ **2.** ___ is the process of removing air and moisture from air conditioning and refrigeration systems.
- A. Vacuum
- B. Recovery
- C. Evacuation
- D. Rehydration

_______________ **3.** ___ causes the formation of hydrofluoric and hydrochloric acids in a system.
- A. Oil
- B. Refrigerant
- C. Moisture
- D. High temperature

_______________ **4.** A low-pressure (compound) gauge and connecting hose are ___ in color.
- A. black
- B. red
- C. blue
- D. yellow

_______________ **5.** A high-pressure gauge typically provides pressure readings from ___ to ___.
- A. 0 in. Hg; 29.92 in. Hg
- B. 0 in. Hg; 150 psi
- C. 0 psi; 500 psi
- D. 29.92 in. Hg; 150 psi

_______________ **6.** A(n) ___ leak detector detects the presence of halogen gas.
- A. electronic
- B. fluorescent
- C. bubble
- D. halide torch

_______________ **7.** ___ leak detectors can pinpoint the location of a leak, but not how much or what type of refrigerant is leaking.
- A. Fluorescent
- B. Ultrasonic
- C. Electronic
- D. Halide torch

______ 8. The EPA requires that ___ be installed on all appliances containing Class I and Class II substances.

A. long hoses
B. service apertures
C. process stubs
D. both B and C

______ 9. Since ___, technicians have been required to evacuate air conditioning and refrigeration equipment to established vacuum levels.

A. November 15, 1990
B. July 13, 1993
C. September 21, 1999
D. June 17, 2000

______ 10. The evacuation level of a leaky system cannot exceed ___.

A. 0 psi
B. 14.7 psi
C. 29.92 in. Hg
D. 30 in. Hg

______ 11. Low-pressure appliances must be pressurized to at least ___ before opening.

A. 0 psi
B. 14.7 psi
C. 29.92 in. Hg
D. 30 in. Hg

______ 12. ___ of an air conditioning or refrigeration system is accomplished by evacuating the system to a deep vacuum.

A. Dehydration
B. Pressurization
C. Heat transfer
D. Charging

______ 13. A vacuum pump that is too large creates evacuation vacuum too quickly and will cause moisture in a system to ___.

A. vaporize
B. evaporate
C. condense
D. freeze

______ 14. Water that boils at 212°F at atmospheric pressure boils at ___°F at 29.67 in. Hg vacuum.

A. 0
B. 40
C. 212
D. 282

______ 15. To determine the boiling point of a refrigerant on a pressure-temperature chart, the corresponding temperature at ___ must be found.

A. 0 psi
B. 0 psia
C. 14.7 psi
D. 29.92 in. Hg

8

Core Certification Test Questions

Twenty-five core questions are found on a typical core certification test. The information covered by the core questions includes refrigeration principles, safety, refrigerants, ozone depletion, regulatory requirements, recovery, recycling, reclaiming, and service practices.

Name ______________________________ Date ______________

______________ **1.** ___ are fluorocarbon refrigerants that cause no harm to stratospheric ozone.

A. CFCs
B. HCFCs
C. HFCs
D. Halons™

______________ **2.** The Clean Air Act ___.

A. calls for the phaseout of PFC refrigerant production
B. requires that all leaks be fixed within 30 days
C. requires OSHA to set standards for the recovery of refrigerants prior to appliance disposal
D. prohibits CFC/HCFC venting as of July 1, 1992

______________ **3.** Refrigerant ___ is the type of contamination that is the most difficult for a reclaiming facility to eliminate.

A. with air
B. with moisture
C. from an acid burnout
D. containing particulate contaminants

______________ **4.** ___ is a CFC refrigerant.

A. R-134a
B. R-123
C. R-22
D. R-12

______________ **5.** ___ is an HCFC refrigerant.

A. R-11
B. R-22
C. R-114
D. R-717

______ 6. ___ is an HFC refrigerant.

A. R-134a

B. R-115

C. R-22

D. R-11

______ 7. The strongest evidence that CFCs are in the stratosphere is ___.

A. theory only

B. measurements of CFCs in air samples from the lower atmosphere

C. measurements of CFCs in air samples from the stratosphere

D. measurements of other man-made compounds in air samples from the stratosphere

______ 8. Ozone depletion in the stratosphere is a ___ problem.

A. local

B. regional

C. national

D. global

______ 9. The ozone layer protects the planet's surface from ___.

A. losing oxygen

B. chlorine monoxide

C. UV radiation

D. hydrogen chloride

______ 10. One of the most serious results of damage to the ozone layer is ___.

A. increased growth of marine plants

B. increased volcanic activity

C. increases in human skin cancer

D. higher natural background radioactivity

______ 11. The size (capacity) of a vacuum pump and suction line size determine ___.

A. vacuum polarity

B. evacuation time

C. refrigerant used

D. oil viscosity

______ 12. ___ is the element in refrigerants that causes ozone depletion.

A. Fluorine

B. Chlorine

C. Carbon

D. Hydrogen

______ 13. Some state and local governments may establish laws that ___.

A. counteract EPA regulations

B. are not as strict as the Clean Air Act and EPA regulations

C. contain stricter regulations than the Clean Air Act and EPA regulations

D. supersede EPA regulations

______ 14. Whenever dry nitrogen from a portable cylinder is used in service and installation practice, the most important safety consideration is that ___.

A. the regulator has a new set of gauges

B. the gauges are clean

C. a relief valve is inserted in the downstream line from the pressure regulator

D. no refrigerant lines can leak

__________ **15.** Personal protective equipment (gloves, safety glasses, safety shoes, etc.) must be worn when ___.

A. reporting for work
B. handling and filling refrigerant cylinders
C. climbing ladders
D. lifting

__________ **16.** ___ is a chlorine-free refrigerant.

A. HFC-134a
B. CFC-2
C. HCFC-22
D. HCFC-124

__________ **17.** When leak checking a unit that has lost a complete charge, ___ is/are the gas(es) that would cause the least damage to the environment.

A. dry nitrogen and R-22
B. compressed air and R-12
C. dry nitrogen
D. dry nitrogen and R-12

__________ **18.** When evacuating a system, the use of a large vacuum pump could cause ___ to freeze.

A. trapped oil
B. trapped refrigerant
C. trapped water
D. valves

__________ **19.** In order to verify the allowable refrigeration system test pressure, check ___.

A. with the equipment owner or representative
B. refrigerant pressure tables
C. the design pressure on the equipment nameplate
D. with the local utility company

__________ **20.** To determine the safe pressure for leak testing a system, a technician should use ___.

A. low-side test-pressure data-plate value
B. discharge operating pressure
C. ambient + 30° temperature/pressure value
D. ambient at standby condition

__________ **21.** ___ is a gas that helps form a protective shield around the Earth.

A. Methane
B. Radon
C. Stratospheric ozone
D. Carbon dioxide

__________ **22.** Refrigerant entering the compressor of a refrigeration system is a ___.

A. liquid
B. subcooled liquid
C. subcooled vapor
D. superheated vapor

__________ **23.** The state of refrigerant leaving the condenser of a refrigeration system is ___.

A. low-pressure liquid
B. low-pressure vapor
C. high-pressure liquid
D. high-pressure vapor

_____ **24.** Failure of a system to hold a vacuum at the end of the evacuation process indicates that ___.
- A. the system is ready to be charged
- B. the system has been adequately evacuated
- C. a leak in the system exists
- D. the feed device is plugged

_____ **25.** A system is said to be dehydrated when ___.
- A. the vacuum indicator shows that the required finished vacuum has been reached and held
- B. the vacuum pump has run for at least 12 hours
- C. the manifold suction gauge has held 30 in. Hg vacuum for 2 hours
- D. you are ready to leave for the day

_____ **26.** ___ have the highest ozone depletion potential (ODP).
- A. HCFCs
- B. HFCs
- C. CFCs
- D. Mineral oils

_____ **27.** When ___ is found in the upper stratosphere, it indicates that the ozone layer is being destroyed.
- A. carbon monoxide
- B. nitrous oxide
- C. trioxide
- D. chlorine monoxide

_____ **28.** Of the following refrigerants, ___ has the lowest ODP.
- A. R-22
- B. R-123
- C. R-134a
- D. R-502

_____ **29.** ___ are an effect of stratosphere ozone depletion on the environment.
- A. Volcanic eruptions
- B. Chlorine compounds
- C. Visible light distortions
- D. Reduced crop yields

_____ **30.** The recovery of refrigerants is necessary to ___.
- A. sell appliances
- B. stop Legionnaires' disease from spreading
- C. give refrigerants low ODP additives
- D. provide adequate supplies for service after production bans are in effect

_____ **31.** To stop damage to the stratospheric ozone layer, the United States is ___.
- A. using ground level ozone to rebuild the ozone layer
- B. stopping the production and regulating the use of CFCs
- C. moving away from CFCs and toward Halons™
- D. stopping the production of HFC and HCFC refrigerants

_____ **32.** Equipment covered by EPA regulations includes ___.
- A. only refrigerators and freezers
- B. all air conditioning and refrigeration equipment containing and using CFC refrigerants
- C. all air conditioning and refrigeration equipment containing and using CFC and HCFC refrigerants
- D. only commercial air conditioning and refrigeration equipment

_______________ **33.** The EPA classifies ___ as a "low-pressure refrigerant."

A. R-134a
B. R-123
C. R-22
D. R-500

_______________ **34.** A ternary blend of refrigerants can be described as a(n) ___ mixture.

A. azeotropic
B. two-part
C. three-part
D. four-part

_______________ **35.** Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are similar in that ___.

A. they have the same ozone depletion potential
B. they both contain hydrogen
C. both must be recovered before opening or disposing of appliances
D. they have the same saturation pressure at 70°F

_______________ **36.** During the servicing of a refrigeration system containing R-12, the refrigerant must be ___.

A. replaced with R-134a
B. recovered
C. vented
D. destroyed

_______________ **37.** The oils that are used with most HFC-134a refrigerant applications are ___.

A. esters
B. alkylbenzenes
C. whale oils
D. all oils are compatible with HFC-134a

_______________ **38.** ___ is the removal of refrigerant in any condition from a system and storing the refrigerant in an external container without necessarily testing or processing the refrigerant in any way.

A. Recycling
B. Recovering
C. Reclaiming
D. Restoring

_______________ **39.** The high-pressure gauge on a service manifold set has a continuous scale, typically calibrated to read from ___ to ___.

A. 500 microns; 0 psig
B. 0 psi; 200 psi
C. 0 psi; 500 psi
D. 250 psi; 750 psi

_______________ **40.** On a typical gauge manifold set, the high-pressure gauge is color-coded ___.

A. green
B. yellow
C. blue
D. red

_______________ **41.** ___ is a safety precaution that must be followed.

A. Storing cylinders in direct sunlight at a temperature of more than 125°
B. Storing recovered refrigerant in new DOT refrigerant cylinders
C. Shipping refrigerant cylinders in the horizontal position
D. Refraining from using oxygen to purge lines or pressurize systems

__________ **42.** Since 1995, supplies of CFC refrigerants for equipment servicing come from ____.

A. recovery and recycling
B. solvent conversion
C. European chemical manufacturers
D. third world chemical manufacturers

__________ **43.** ____ results in violation of the Clean Air Act.

A. Using dry nitrogen to pressurize systems
B. Having a cylinder that is clearly marked with the chemical name
C. An accusation of misconduct
D. Failing to reach required evacuation levels before opening or disposing of appliances

__________ **44.** An award of up to $____ may be paid to a person supplying information that leads to penalties against a technician who is intentionally venting.

A. 5000
B. 10,000
C. 25,000
D. 50,000

__________ **45.** Proper disposal of refrigerant cylinders is accomplished by ____.

A. bleeding refrigerant to ambient air and throwing the cylinders into a trash dumpster
B. ensuring that all refrigerant is recovered and that the cylinders are rendered useless, then recycling the metal
C. refilling the cylinders a second time at an approved facility
D. giving the cylinders to a reclaiming facility for reuse

__________ **46.** Before a technician disposes of any appliance containing a CFC or HCFC refrigerant, the technician must ____.

A. recover the refrigerant
B. purge the appliance with nitrogen
C. flush the appliance with R-11
D. seal the appliance so no refrigerant can escape

__________ **47.** Blended refrigerants must be charged ____.

A. as a vapor
B. at very high temperatures
C. by weight into the high-pressure side of the system as a liquid
D. the same as any other refrigerant

__________ **48.** Blended refrigerants leak from a system ____.

A. at a faster rate than other refrigerants
B. in uneven amounts due to different vapor pressures
C. at a slower rate than other refrigerants
D. only if the line breaks completely

__________ **49.** Refrigerant will migrate to the crankcase of a compressor because of the difference in ____ between the oil and the refrigerant.

A. vapor pressure
B. acidity
C. volume
D. density

_______________ **50.** Recycling is to ___.

A. remove refrigerant, in any condition, from a system and store it in an external container, without necessarily testing it or processing it in any way

B. process refrigerant to a level equal to new product specifications and test it to verify purity

C. clean refrigerant by oil separation and single or multiple passes through moisture-absorption devices and then reuse the refrigerant

D. remove refrigerant from job site for disposal

_______________ **51.** While servicing a system, a technician discovers that R-502 refrigerant was added to a system with R-22 refrigerant. The technician must ___.

A. vent the refrigerant since it cannot be reclaimed

B. recycle the refrigerant

C. recover the refrigerant into a separate tank

D. recover and use the refrigerant in another system

_______________ **52.** A factor affecting the speed of evacuation is the ___.

A. boiling temperature of the refrigerant

B. manufacture date of the HVAC equipment

C. condenser location

D. diameter of the hoses

_______________ **53.** When operating refrigerant recovery or recycling equipment, ___ is a safety precaution that must be followed.

A. using standard colored hoses

B. keeping the high-pressure (red) valve open at all times

C. having the relief valve at the highest point in the system

D. wearing protective gloves

_______________ **54.** A refrigerant label is placed on a ___.

A. refrigerant cylinder to be returned for reclaiming

B. truck to identify the cylinder hauler

C. cylinder to identify gross weight

D. cylinder to identify pressure

_______________ **55.** According to the EPA, it has been illegal to vent substitutes for CFC and HCFC refrigerants since ___.

A. July 1, 1992

B. July 1, 1993

C. November, 1993

D. November, 1995

_______________ **56.** The Montreal Protocol is ___.

A. a treaty among nations that controls production of chlorofluorocarbons and hydrochlorofluorocarbons

B. a test for energy efficiency adopted by the Canadian government

C. a procedure for measuring levels of CFCs in the atmosphere

D. a test for ozone concentration

_______________ **57.** "System-dependent" recovery devices ___.

A. are hermetically sealed units requiring special maintenance

B. must be connected to the liquid port on large systems

C. capture refrigerant with the assistance of components in the air conditioning and refrigeration system

D. must be plugged into a power source

______ **58.** An azeotropic mixture is a mixture that ___.

A. raises the refrigerant's boiling point

B. raises the refrigerant's pressure

C. lowers both boiling point and pressure of the refrigerants

D. combines two refrigerants that create a third refrigerant with its own individual characteristics

______ **59.** When a refrigerant blend has a range of boiling points or condensing points in the evaporator and condenser, respectively, the term used to describe the range is ___.

A. pressure slump

B. mixture glide

C. fractionation

D. temperature glide

______ **60.** A compound pressure gauge for the low-pressure side of a system measures pressure in ___.

A. psia

B. torrs and microns

C. psi and inches of mercury

D. microns

______ **61.** To reclaim a refrigerant is to ___.

A. remove refrigerant, in any condition, from a system and store it in an external container, without necessarily testing or processing the refrigerant in any way

B. process refrigerant to a level equal to new product specifications as determined by chemical analysis

C. clean refrigerant by oil separation and single or multiple passes through moisture-absorption devices and then reuse the refrigerant

D. remove refrigerant from the job site for disposal

______ **62.** ___ is/are the leak detection method considered to be the most effective for locating the general area of small leaks.

A. Bubble test

B. Electronic/ultrasonic testers

C. Halide torch

D. Audible sound

______ **63.** Long hoses between the air conditioning or refrigeration unit and the recovery machine should be avoided because long hoses cause ___.

A. ice to form in the recovery machine

B. compressor oil to be trapped in bypass

C. vibrations throughout the refrigeration unit

D. excessive pressure drops

______ **64.** The piping connection to a vacuum pump must be ___.

A. as short in length and as large in diameter as possible

B. a suitable size to connect to a gauge manifold

C. coiled and taped together

D. colored red or blue to meet codes

______ **65.** Whenever working with any solvents, chemicals, or refrigerants, the technician must review ___ sheets.

A. moisture solubility data

B. chemical compound reference

C. material safety data

D. chemical composition reference

_______________ **66.** When transporting cylinders containing used refrigerant, the DOT requires that technicians ___.

A. use OSHA-approved containers
B. attach DOT classification tags
C. ship by EPA-certified carriers
D. ensure pressurization with dry nitrogen to 120 psi

_______________ **67.** Compared to CFCs, HCFC refrigerants are ___ harmful to stratospheric ozone.

A. more
B. just as
C. less
D. not at all

_______________ **68.** An increase in ultraviolet radiation could result in an increase in the number of ___.

A. cataracts cases
B. cases of infertility
C. cases of heat prostration
D. thyroid disorders

_______________ **69.** CFCs were not manufactured or imported into the U.S. after ___.

A. 1994
B. 1995
C. 1996
D. 2000

_______________ **70.** On July 1, 1992, it became illegal to ___.

A. use CFC or HCFC refrigerants
B. manufacture CFC or HCFC refrigerants in the U.S. or import them
C. knowingly release CFC or HCFC refrigerants during the service, maintenance, repair, or disposal of appliances
D. charge CFC refrigerants into a system

_______________ **71.** A refrigerant oil that is hygroscopic ___.

A. is a good lubricant
B. is crude oil and unrefined
C. has a high affinity for water
D. can be left open to the ambient air

_______________ **72.** Ester-base oils can be mixed with ___.

A. pag oils
B. paraffinic mineral oils
C. alkylbenzene oils
D. no other oils

_______________ **73.** ___ is the cleaning of refrigerant by oil separation and single or multiple passes through devices like replaceable-core filter/dryers, which reduce moisture and acidity for immediate reuse in the same facility.

A. Recycling
B. Recovering
C. Reclaiming
D. Restoring

_____ **74.** Recovering refrigerant during low ambient temperatures will ___.

A. shorten recovery time
B. slow the recovery process
C. minimize emissions
D. require frequent dryer changes

_____ **75.** According to the ASHRAE refrigerant safety classification standard, Class ___ refrigerants are the most safe.

A. A-1
B. A-3
C. B-1
D. B-3

_____ **76.** Technicians must not use oxygen or compressed air to pressurize appliances to check for leaks because ___.

A. when mixed with compressor oil, oxygen and compressed air can explode
B. leaking oxygen and compressed air are difficult to detect
C. the pressures produced by oxygen and compressed air are not acceptable
D. oxygen and compressed air do not mix well with refrigerants

_____ **77.** Ozone in the stratosphere above the Earth consists of ___.

A. molecules containing three oxygen atoms
B. molecules containing two oxygen atoms
C. radioactive particles
D. pollutants that have risen from ground level

_____ **78.** Refrigerant entering the metering or expansion device of a refrigeration system is a ___.

A. liquid
B. saturated vapor
C. superheated vapor
D. mixture of vapor and liquid

_____ **79.** The Montreal Protocol controls ___.

A. all refrigerants
B. all oils
C. standard procedures to be followed
D. ozone-depleting substances

_____ **80.** The center port on a three-port manifold is used for ___.

A. obtaining gauge readings
B. pumping air into a system
C. bypass from low to high side
D. recovery, evacuation, and charging

_____ **81.** ___ refrigerant(s) may be recovered into a recovery cylinder.

A. Only one type of
B. Two different types of
C. Any number of CFC
D. Any number of non-CFC

_______________ **82.** In most refrigerant accidents where death occurs, the major cause is ____.

A. toxic poisoning
B. oxygen deprivation
C. refrigerant burn
D. heart failure

_______________ **83.** Refrigerant cylinders must be shipped in the ___ position.

A. inverted
B. upright
C. horizontal
D. diagonal

_______________ **84.** All devices used for refrigerant recovery must ____.

A. be portable
B. contain a heavy-duty shield
C. have a 20,000 Btu/hr rating
D. meet EPA standards

_______________ **85.** The component that changes low-pressure vapor to high-pressure vapor is the ____.

A. evaporator
B. condenser
C. cap tube
D. compressor

_______________ **86.** During dehydration of a refrigeration system, the refrigeration system may be heated to ____.

A. prevent oxidation
B. increase oil viscosity
C. decrease dehydration time
D. increase dehydration time

_______________ **87.** ____ is a suitable substitute refrigerant for R-12 with system modifications.

A. PFC-512
B. HFC-125
C. HCFC-22
D. HFC-134a

_______________ **88.** Overevacuation of a system ____.

A. causes tube collapse
B. damages vacuum gauges
C. causes vacuum pump damage
D. does not occur

_______________ **89.** When transferring refrigerant to a pressurized cylinder, the safe filling level can be controlled by ____.

A. a sight glass
B. time
C. ice
D. a scale

______________ **90.** The main reason why a technician must never heat a refrigerant storage or recovery tank with an open flame is that ___.

A. it can result in venting refrigerant to the atmosphere
B. the tank may explode, seriously injuring people in the vicinity
C. the tank could be damaged, rendering it unusable
D. the refrigerant in the tank may decompose, forming a toxic material

______________ **91.** The synthetic lubricants presently used with HCFC ternary blends are ___ lubricants.

A. alkylbenzene
B. glycol
C. ester
D. whale oil

______________ **92.** Measuring system vacuum is accomplished with ___.

A. the vacuum pump on
B. the vacuum pump off
C. the system heated
D. a gauge as close as possible to the vacuum pump

______________ **93.** Reusable containers for refrigerants that are under high pressure (above 15 psi) at normal ambient temperature must be hydrostatically tested and date stamped every ___ years.

A. 1
B. 2
C. 5
D. 10

______________ **94.** Disposable refrigerant containers are used for ___ refrigerant.

A. recycled
B. recovered
C. new
D. CFC

______________ **95.** The reason for dehydrating a refrigeration system is to remove ___.

A. water and water vapor
B. oil and oil vapor
C. refrigerant and refrigerant vapor
D. particulates

______________ **96.** Technicians may use a disposable cylinder to recover refrigerant ___.

A. when the system contains the same refrigerant as the cylinder
B. when the system contains less than 10 lb of refrigerant
C. only in an emergency
D. never

______________ **97.** A refillable refrigerant cylinder must not be filled above ___% of its capacity by weight.

A. 50
B. 70
C. 80
D. 95

__________ **98.** ___ is considered a Class I substance.

A. R-12
B. R-22
C. R-123
D. R-407c

__________ **99.** If refrigerants are mixed during recovery, the refrigerants ___.

A. can be used as a blend
B. cannot be reclaimed and incineration may be required
C. will separate during storage
D. will be explosive

__________ **100.** ___ must be recovered before opening or disposing of appliances.

A. Lubricating oil
B. Compressor oil
C. Electric motors
D. Refrigerants

__________ **101.** When scrapping a disposable cylinder, the cylinder pressure must be at ___ psi.

A. 0
B. 20
C. 50
D. 80

__________ **102.** A technician who is fined, loses his/her certification, and is required to appear in federal court has probably ___.

A. worked for more than three HVAC service companies
B. faced an EPA review board
C. violated OSHA regulations
D. violated Clean Air Act provisions

__________ **103.** Measuring final system vacuum is accomplished with the ___.

A. gas ballast open
B. vacuum pump operating
C. system heated
D. system isolated and the vacuum pump turned off

__________ **104.** During dehydration or system evacuation, vacuum lines (hoses) must be ___.

A. orange in color for safety reasons
B. as long as possible
C. smaller than the pump intake connections
D. equal to or larger than the pump intake connections

__________ **105.** The smallest container in which refrigerants may be sold to a Section 608 certified technician is ___ lb.

A. 1
B. 10
C. 15
D. 20

_______________ **106.** CFCs are more likely to reach the stratosphere than other compounds containing chlorine because CFCs ___.

A. do not dissolve in water or break down into compounds that dissolve in water, so CFCs do not rain out of the atmosphere

B. are lighter than other chlorine compounds, making it easier for them to float upward when released

C. are stored under pressure, causing them to jet upward when released

D. are attracted to ultraviolet radiation

_______________ **107.** ___ is a release of CFC or HCFC refrigerant that is a violation of the prohibition on venting.

A. Release of "de minimis" quantities in the course of making good faith attempts to recapture and recycle or safely dispose of refrigerant

B. Release of a nitrogen and refrigerant mixture that results from adding nitrogen to a charged appliance to check for leaks

C. Refrigerants vented in the course of normal operation of an appliance

D. Refrigerants emitted when connecting or disconnecting hoses to charge or service an appliance

_______________ **108.** Upon completing the transfer of liquid refrigerant between the recovery unit and the refrigeration system, a technician must guard against trapping ___.

A. oil in the transfer unit receiver

B. oil in the refrigeration system's cooler

C. liquid refrigerant in the compressor or between service valves

D. liquid refrigerant in the recovery receiver

_______________ **109.** When addressing consumer questions regarding additional service expense due to recovery efforts, technicians must explain that ___.

A. the system is somewhat large and refrigerant recovery can take hours

B. the system is quite old and standard practices must be slowed to accommodate the system

C. the system is complex and it takes time to go through it

D. all professional HVAC service personnel are duty bound to follow the law and protect the environment

_______________ **110.** Care must be taken not to overfill reusable containers because ___.

A. the cylinder may be too heavy to lift

B. the internal pressure of the cylinder may rise in heated areas and cause an explosion

C. some refrigerant may be vented when closing the valves

D. the excess space may be needed for refrigeration for the next job

_______________ **111.** An oil sample should be taken because ___.

A. a new filter/dryer has been installed

B. the unit has had a leak or major component failure

C. the unit is not cooling properly

D. recycled refrigerant has been added to the unit

_______________ **112.** When an operating refrigeration system contains moisture, the moisture will cause ___.

A. copper tubes and fittings to rust

B. compressor discharge valves to freeze up

C. acids to form

D. compressor head pressures to rise

______________________ **113.** Refrigerant vapors or mist in high concentrations must not be inhaled because refrigerant vapors ___.

A. are addictive

B. lower body temperature

C. cause heart irregularities or unconsciousness

D. cause skin cancer

______________________ **114.** For accurate readings during evacuation, the system vacuum gauge should be connected ___.

A. at the pump discharge

B. as far from the vacuum pump as possible

C. directly to the pump suction

D. anywhere in the evacuation service hose

______________________ **115.** R-134a refrigerant charged systems should be leak checked with ___.

A. CFCs

B. HCFCs

C. pressurized nitrogen

D. compressed dry air

______________________ **116.** All recovery equipment manufactured today is required to have ___.

A. a calibration stamp or label

B. an EPA approved equipment testing organization certification label

C. oil-less compressors

D. manual triple shutoffs and triple seal isolation valves

______________________ **117.** Cooling of the medium occurs in a direct-expansion vapor-compression refrigeration system when ___.

A. refrigerant vapor turns to a liquid

B. the refrigerant is under maximum pressure

C. liquid refrigerant turns to a vapor

D. the refrigerant gives off heat

______________________ **118.** When corrosion buildup is found within the body of a relief valve, the valve must be ___.

A. repaired

B. reconditioned

C. cleaned

D. replaced

______________________ **119.** EPA regulations require the installation of a service aperture or process stub on all appliances using Class I or Class II refrigerants for ___.

A. recovering refrigerants

B. checking for open motor windings

C. venting noncondensables

D. dehydrating the system

______________________ **120.** On a typical gauge manifold set, the low-pressure gauge is color-coded ___.

A. green

B. yellow

C. blue

D. red

_______________ **121.** When recovering refrigerant, it is important not to mix different refrigerants in the same container because ____.

A. the mixture would explode
B. the mixture probably is impossible to reclaim
C. the refrigerant mixture is toxic
D. it is a violation of the EPA environmental regulations

_______________ **122.** A violation of the Clean Air Act, such as the knowing release of refrigerant during the maintenance, service, repair, or disposal of appliances, can result in fines up to ____.

A. $1000 per day per violation
B. $10,000 per day per violation
C. $32,000 per day per violation
D. fines are never issued

_______________ **123.** A refrigerant cylinder that has a gray body and a yellow top indicates the cylinder is designed to hold ____.

A. acetylene
B. nitrogen
C. only refrigerant R-143a
D. recovered refrigerant

_______________ **124.** Ozone depletion potential or "ODP" is ____.

A. the same as global warming potential or "GWP"
B. a measurement of a refrigerant's ability to destroy ozone
C. a rating of health hazards caused by ozone depletion
D. a rating of smog pollution concentrations

_______________ **125.** Refrigerant R-22, although considered to be non toxic, ____.

A. can cause oxygen deprivation (asphyxia)
B. is a Class I refrigerant
C. can be detected by its color
D. is lighter than air

_______________ **126.** Which refrigerant contains CFC's?

A. R-500
B. R-22
C. R-134a
D. R-123

_______________ **127.** Chlorine in the stratosphere is believed to come primarily from CFCs rather than natural sources such as volcanoes because ____.

A. the rise in the amount of chlorine measured in the stratosphere over the past two decades matches the rise in the amount of fluorine over the same period
B. volcanoes do not contain the highest concentrations of chlorine in the stratosphere
C. oceans have chlorine molecules rising with the water molecules of evaporation
D. more pools are being installed every day

_______________ **128.** Recovery equipment typically has desiccant packages to trap moisture and an in-line particulate filter that has a rating of ____.

A. 300 psi
B. 400 psi
C. 15 microns
D. 40 microns

9 Type I (Small Appliances)

Type I (small appliances) is the EPA classification consisting of small capacity refrigeration appliances used mostly in residential systems. The refrigerator in a kitchen or a window air conditioner in a room are examples of small appliances. The size of the equipment along with the amount of refrigerant charge inside the equipment mean there are unique considerations when servicing or repairing small appliances.

TYPE I (SMALL APPLIANCES) CLASSIFICATION

Type I (small appliances) are refrigeration products that are fully manufactured, charged, and hermetically sealed in a factory with 5 lb or less of refrigerant. Technicians passing the core test and small appliance (Type I) test for the EPA are certified to recover refrigerant during the maintenance, service, or repair of the following:

- refrigerators
- freezers designed for home use
- room air conditioners (including window air conditioners and packaged terminal air conditioners)
- packaged terminal heat pumps
- dehumidifiers
- under-the-counter icemakers
- vending machines
- drinking water coolers

Service Apertures

All small appliances must be equipped with a service aperture. A *service aperture* is a device used to add or remove refrigerant from a system. Small appliances typically have a service aperture, which consists of a straight piece of tubing that is entered by using a piercing access valve.

> *A packaged terminal air conditioner (PTAC) can be serviced by a Type I technician only if the PATC is designed to contain 5 lb or less refrigerant. Motor vehicle air conditioning (MVAC) systems and the like are not Type I appliances.*
>
> **Technical Fact**

Piercing Access Valves

To gain access into the sealed system of a small appliance, a piercing access valve is used. Piercing access valves are installed on service apertures or suction lines of a system. When installing a piercing access valve onto a sealed system, the valve must be leak tested before proceeding with refrigerant recovery. In general, piercing-type valves should be used only on ¼″,

5⁄16", and 3⁄8" tubing made of copper or aluminum. Once a piercing access valve has been installed, leak tested, and opened, system pressure must be verified. If the system pressure of a small appliance is 0 psi, the recovery procedure should not be started. The recovery procedure should not be performed because 0 psi in a small appliance indicates there is no refrigerant in the system to recover.

If a solderless-type access valve is used, the solderless valve must not remain installed on the system after completion of repairs. Solderless-type access valves leak over time due to vibrations and therefore are considered temporary access valves. **See Figure 9-1.** When a permanent valve is required, a soldered Schrader valve or saddle-type access valve is used. Schrader-type access valves that are soldered in position use a piercing pin to gain access into the system.

Refrigerants have no odor. When a pungent odor is detected, typically a compressor burnout has contaminated the refrigerant.

Technical Fact

Recommended safe work practices when recovering refrigerants include the following:

- *wearing safety glasses or goggles when working with any compressed gas*
- *wearing butyl-lined gloves when connecting or disconnecting a hose*

Technical Fact

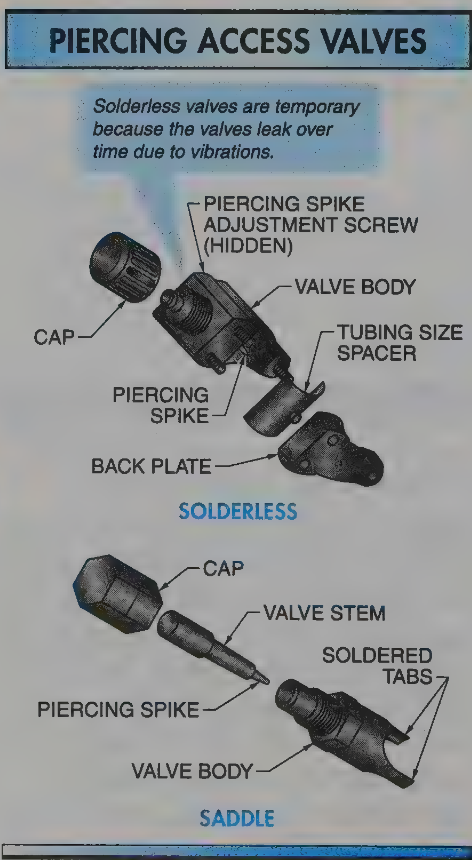


Figure 9-1. Piercing-type access valves are used to gain access into the system of a small appliance.

Small Appliance Refrigerants

Beginning November 14, 1994, the sale of CFC and HCFC refrigerants was restricted to technicians certified in refrigerant recovery and handling. Air conditioners typically use R-22 refrigerants and refrigerators use R-12 refrigerants. R-134a is a common retrofit replacement for R-12 refrigerant in household refrigerators. Because of the differences between R-12 and R-134a refrigerants, there are no "drop-in" replacements for R-12 refrigerants, only "retrofit" replacements.

REGULATORY REQUIREMENTS

Technicians servicing small appliances must be certified in refrigerant recovery if the technician is to perform work on a sealed system after November 14, 1994. If any EPA regulations change after a technician becomes certified, it is the responsibility of the technician to comply with any changes to the law.

Recovery and Recycling

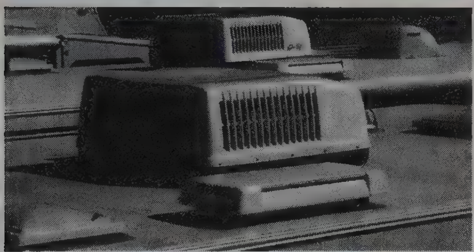
Recovery equipment such as a recovery machine, scale, storage cylinder, hoses, vacuum pump, and gauge sets are used during the maintenance, service, and repair of small appliances. All recovery equipment must be certified by an EPA-approved laboratory if manufactured after November 15, 1993.

Recovery Machines

New recovery machines are not compatible with the older refrigerator refrigerants that will harm or destroy recovery machines and devices manufactured today. Refrigerants used in refrigerators built before 1950 must not be recovered with recovery machines manufactured today. The refrigerants found in refrigerators built before 1950 are sulfur dioxide, methyl chloride, and methyl formate.

Refrigerants used in current small appliances such as campers or recreational vehicles must not be recovered without refrigerant-specific approved recovery machines and devices. The refrigerants found in campers and recreational vehicles are ammonia, hydrogen, and water. New recovery devices are not compatible with camper and recreational vehicle refrigerants. Specific recovery machines must be used that are designed to work with ammonia or with hydrogen. **See Figure 9-2.**

SPECIALTY RECOVERY MACHINES



CAMPER AIR CONDITIONER

Yellow Jacket Div., Ritchie Engineering Co., Inc.

SPECIALTY RECOVERY MACHINE

Figure 9-2. Refrigerants used in small appliances such as campers or recreational vehicles must be recovered with refrigerant-specific approved recovery machines.

EPA RULE CHANGE

40 CFR Part 82

EPA has clarified that what was formerly referred to as an "off-site recycling standard" is essentially reclamation by a technician or contractor, instead of reclamation by a certified reclaimer. EPA and industry have distinguished between recycling and reclamation. To recycle refrigerant means to extract refrigerant from an appliance and to clean the refrigerant for reuse without meeting the requirements for reclamation. Recycled refrigerant is cleaned using oil separation and one or more passes through recycling devices. Recycling procedures are usually performed at the job site. Reclamation means that the refrigerant has been cleaned and chemically analyzed for conformity with the ARI Standard 700-1993 purity levels. Hence, refrigerant that has been cycled through recycling equipment and tested to ensure that ARI Standard 700-1993 has been achieved is actually reclaimed refrigerant. Therefore, henceforth EPA will refer to this procedure as contractor reclamation, or contractor reclaiming rather than off-site recycling.

EPA is proposing that when the refrigerant remains in the custody of a single technician or contractor and a representative sample of that refrigerant has been chemically analyzed to determine conformance with the ARI Standard 700-1993, the refrigerant will be considered reclaimed and may be charged into a new owner's appliance. A representative sample may be defined as a sample taken from each container of refrigerant to be chemically analyzed and tested to ARI Standard 700-1993 prior to packaging for resale or reuse. Such samples will be at least 500 ml and shipped in stainless steel test cylinders that include a ¼" valve assembly and pressure relief rupture disc. EPA believes that as long as representative samples of the refrigerant are chemically analyzed by certified laboratories to meet the contaminant levels in ARI Standard 700–1993, and as long as refrigerant remains in the contractor's custody and control, the quality and purity of the reclaimed refrigerant can be ensured.

Environmental Protection Agency

Shipping Refrigerant Containers

Portable refillable cylinders, tanks, or containers used to ship CFC or HCFC refrigerants must meet Department of Transportation (DOT) standards. Before shipping any used refrigerant, the technician must:

- Properly label the refrigerant container. **See Figure 9-3.**
- Properly complete shipping paperwork.
- Check that the refrigerant container meets DOT standards.

The Department of Transportation Regulations, 49 CFR, require the weight of each cylinder or shipping container to be recorded on the shipping paperwork for hazardous class 2.2, nonflammable compressed gases.

When refrigerant, such as R-500, is recovered from an appliance, it must be recovered into its own recovery vessel that is clearly marked to ensure that refrigerants do not mix. Refrigerants must never be mixed in recovery vessels.

▶ Technical Fact

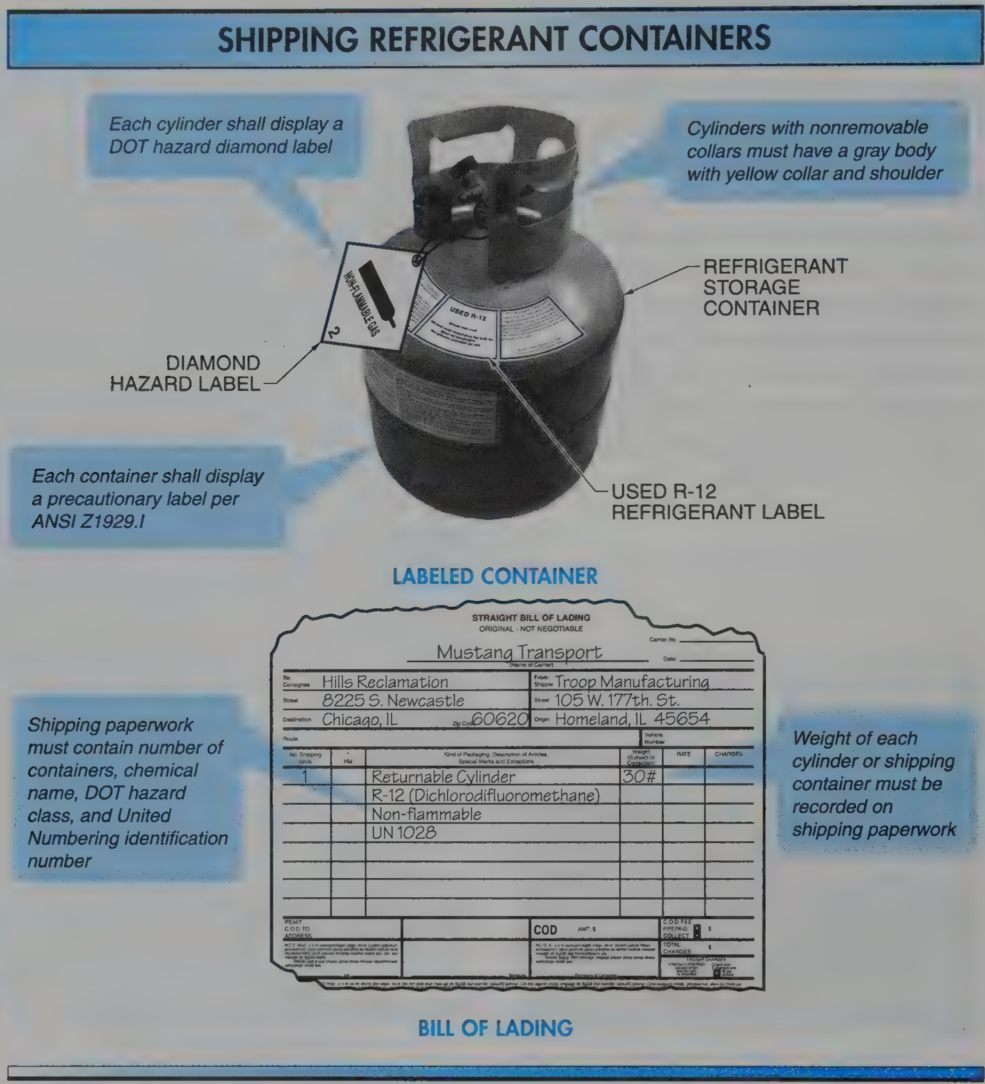


Figure 9-3. Portable refillable cylinders, tanks, or containers used to ship CFC or HCFC refrigerants must meet Department of Transportation (DOT) standards by having the proper paperwork and labels.

Devices used for monitoring the 80% fill level in a recovery tank are float devices, scales, and thermistors.

Technical Fact

If a reclamation facility receives a container of mixed refrigerants, the reclamation facility may refuse to process the refrigerant mixture. The unprocessed refrigerant mixture is returned to the owner of the refrigerant at the expense of the owner. The refrigerant owner and reclamation facility can agree to destroy the refrigerant mixture instead of returning the mixture. Reclamation facilities charge a substantial fee for destroying refrigerant.

Standard vacuum pumps can be used to recover refrigerant from a small appliance if used with a nonpressurized storage container.

Technical Fact

RECOVERY REQUIREMENTS FOR SMALL APPLIANCE DISPOSAL

Under Section 608 of the Clean Air Act, recovery equipment used to recover CFC, HCFC, and HFC refrigerants from small appliances prior to final disposal must meet the same performance standards as recovery equipment used for servicing small appliances. The recovery machines used for recovering refrigerants from

small appliances destined for disposal does not have to be tested by a laboratory. To ensure that technicians are recovering the correct percentage of refrigerant by either recovery method, technicians must use recovery equipment according to industry standards. **See Figure 9-4.**

Small Appliance Components

Small appliances have refrigeration systems made up of the same components as other refrigeration systems. Small appliance systems have compressors, condensers, metering devices, and evaporators. The compressor used in a small appliance typically is a hermetically sealed reciprocating compressor or rotary compressor. The condensers of small appliances are air-cooled fin-and-tube heat exchangers. Metering devices are typically capillary tubes and the evaporators of small appliance systems are dry (direct) expansion-type, fin-and-tube heat exchangers.

SMALL APPLIANCE SERVICE PRACTICES

Leak testing, recovery, evacuation, and charging are service practices that are performed on all equipment. However, when servicing small appliances, certain procedures are performed that are unique to small appliances. Regulations also have an effect on how a technician performs certain practices on small appliances.

Small Appliance Leak Repairs

A technician servicing a small appliance to repair a leak is not obligated by the EPA to repair the leak immediately. Leak repairs only have to be performed on refrigeration equipment with 50 lb or more of refrigerant. Because small appliances have a maximum of 5 lb of refrigerant charge, the EPA allows small appliance leaks to be repaired whenever possible.

Pressure Readings from Recovery Cylinders

Technicians can obtain pressure readings from recovery cylinders. Accurate pressure readings of the refrigerant inside a recovery cylinder are important for the following reasons:

- pressure readings can indicate if excessive air or other noncondensables are present in the cylinder
- pressure readings can indicate if the refrigerant has been broken down (made unusable)

When a refrigerant cylinder ruptures (far worse than a compressed-air cylinder rupture of the same pressure), the pressure drop causes the liquid refrigerant to flash into vapor and sustains the explosive behavior of the rupture until all the liquid is vaporized.

Technical Fact

Technicians must vacate and ventilate the area of a refrigerant spill if no breathing apparatus is available.

Technical Fact

Refrigerants leaking from a system or cylinder in large quantities can cause suffocation because refrigerants are heavier than air and displace oxygen. At high temperatures, R-12 and R-22 refrigerants can decompose to form phosgene gas, hydrochloric acid, or hydrofluoric acid.

Technical Fact

ARI 740 — PLANNED SMALL APPLIANCE EVACUATIONS		
Compressor Status	Equipment Manufactured before November 15, 1993	Equipment Manufactured on or after November 15, 1993
Operational	80% refrigerant recovered or 4″ Hg	90% refrigerant recovered or 4″ Hg
Nonoperational	80% refrigerant recovered or 4″ Hg	80% refrigerant recovered or 4″ Hg

Figure 9-4. To ensure that technicians are recovering the correct percentage of refrigerant, technicians must use recovery equipment according to industry standards and evacuation requirements.

When filling a graduated charging cylinder, refrigerant that is vented off the top of the cylinder must be recovered.

▶ Technical Fact

To ensure liquid R-12 is being charged into a small appliance, the refrigerant cylinder should be inverted.

▶ Technical Fact

Accurate pressure readings are only possible if the refrigerant in the recovery cylinder is allowed to stabilize to ambient temperature before any comparisons to a pressure-temperature chart are made. **See Figure 9-5.** Comparisons to a pressure-temperature chart are typically made when both pressure and temperature in the recovery cylinder are known to be stable.

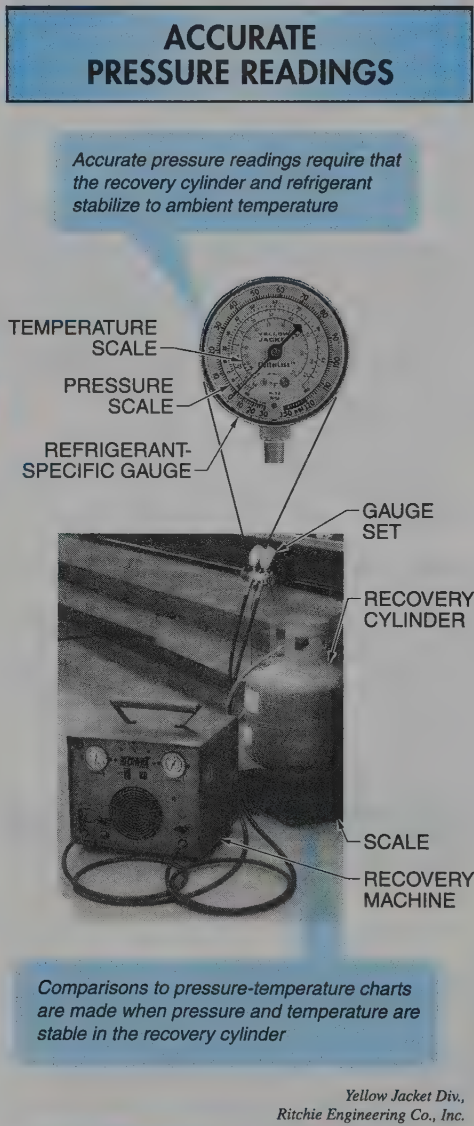


Figure 9-5. Accurate pressure readings are taken when the refrigerant in a recovery cylinder is allowed to stabilize to ambient temperature.

Schrader valve cores can be removed to decrease the time it takes to evacuate a system.

▶ Technical Fact

The following are examples of typical storage cylinder pressures and temperatures:

- A full storage cylinder of recovered R-12 refrigerant at a room temperature of 75°F, with no noncondensables, should have a pressure of approximately 75 psi.
- A full storage cylinder of recovered R-22 refrigerant at a room temperature of 75°F, with no noncondensables, should have a pressure of approximately 130 psi.

Technicians recovering refrigerant into nonpressurized containers from small appliances such as refrigerators that have inoperative compressors are required to store the refrigerant in a separate recovery container because the refrigerant may be contaminated.

Schrader Valves

When using recovery cylinders and equipment with Schrader valves (flared or compression fitting), it is critical to:

- Inspect Schrader valve cores for bends and breakage.
- Replace damaged Schrader valve cores to prevent leakage. **See Figure 9-6.**
- Cap the Schrader valve ports to prevent accidental damage to the valve core and refrigerant leaking.

Servicing Small Appliances

A sealed system of a small appliance with an operating compressor and a completely restricted capillary tube metering device requires only one access valve on the high-pressure side of the system to evacuate the refrigerant.

SCHRADER VALVES

Yellow Jacket Div., Ritchie Engineering Co., Inc.

Figure 9-6. When Schrader valves (flared or compression fitting) are used with recovery equipment, valve ports must be capped, valve cores inspected, and damaged cores replaced with core removal tools.

EPA FINAL RULE—SCHRADER VALVES

40 CFR Part 82

Several EPA advisors believe that the use of Schrader valves (flared or compression fittings) for clamp-on piercing access valves should be prohibited. Valve cores restrict the flow of liquid refrigerant and provide easy access for vandals. Adapters for charging hoses are not 100 percent leak-free as some adapters trap the refrigerant in the hose, which allows for possible cross-contamination into other, clean systems.

However, several EPA advisors stated that Schrader valves should not be prohibited, and that it is the technician and not the valve that is the problem. If the isolated portion of the system has been pumped down to atmospheric pressure, then there is little or no loss when there is a need to remove the valve stem. Other advisors stated that the Schrader valves are effective devices that actually minimize leaks, and although they tend to slow the process of recovering refrigerant, there are devices that will remove the valve core to speed up the process.

The EPA does not prohibit the use of Schrader valves on small appliances. EPA believes that such valves assist in the recovery of refrigerant, and that concerns for their release of refrigerant can be minimized through proper use. All Schrader valves should be capped while not in use.

Environmental Protection Agency

When a technician checks the pressure of a refrigeration system to determine system performance, the technician must use equipment such as manual isolation valves and self-sealing hoses to minimize the possibility of any refrigerant releases. **See Figure 9-7.**

A two Schrader valve refrigerant recovery procedure requires that a valve be installed just upstream of the expansion valve, with a second Schrader valve being installed between the compressor and condenser.

▶ Technical Fact

SELF-SEALING MANUAL ISOLATION VALVES

Yellow Jacket Div., Ritchie Engineering Co., Inc.

Figure 9-7. When a technician checks the pressure of a refrigeration system, the technician must use equipment such as self-sealing manual isolation valves and self-sealing hoses to minimize the possibility of any refrigerant releases.

When a household refrigerator compressor will not run, it is recommended that low pressure and high pressure side access valves be installed to recover refrigerant from the system. This is because the valves will enhance the speed of recovery and may be necessary to achieve the recovery efficiency required.

▶ Technical Fact

SPX Ronbinair

After all refrigerant has been recovered from a small appliance, the system can be power flushed or nitrogen can be used to clean debris from the system caused by compressor burnout.

Recovery Speed

To increase the speed of refrigerant recovery and ensure that all refrigerant has been removed from a small appliance such as a frost-free freezer, a technician can turn the defrost heater of the small appliance ON to vaporize any trapped liquid refrigerant in the system. After recovering the entire refrigerant charge from the sealed system, nitrogen can be used to pressurize or blow debris out of the system. The nitrogen can be vented to the atmosphere as long as the nitrogen is not contaminated.

> *Processing times (speed of refrigerant recovery) of 1.5 lb/min to 3 lb/min of vapor/minute, or 3 lb/min to 5 lb/min of liquid/minute, are typical for small appliances.*
>
> ▶ Technical Fact

> *Small appliances may require flushing if contaminants are found in the refrigerant.*
>
> ▶ Technical Fact

Recovery Regulations

Small appliances are allowed to have refrigerant recovered using the passive method of recovery. The passive method of refrigerant recovery can only be used when less than 15 lb of refrigerant will be recovered from the high-pressure side. Because small appliances can use the passive method of refrigerant recovery, self-contained recovery machines are not always required.

Refrigerant recovery machines must be equipped with special low-loss fittings. Low-loss fittings are used to connect the recovery machine and devices to small appliances while preventing the loss of refrigerant from the connections. Low-loss fittings can be manual or automatic. Manual fittings require a person to close the fitting; automatic fittings close automatically when disconnected.

> *When using nitrogen to test a sealed refrigeration system, the nitrogen tank must be equipped with a regulator. When recovering refrigerant from a system that experienced a compressor burnout, the technician must look for signs of contamination in the oil.*
>
> ▶ Technical Fact

Recovery Practices

Small appliances may be serviced for maintenance or repair only if the following conditions are true or present. **See Figure 9-8.**

- A technician must always know the type of refrigerant that is in a system before beginning the refrigerant recovery process.
- The recovery machine and equipment used must be checked for refrigerant leaks on a regular basis.
- When an excessive pressure condition on the high-pressure side of a self-contained recovery machine is present, the recovery tank inlet valve has not been opened or there is excessive air in the recovery container.
- When performing a system-dependent (passive) recovery process, a technician must run the compressor of the small appliance and recover refrigerant possibly in a nonpressurized

container, from the high-pressure side of the system.

- When a system compressor is inoperative, piercing access valves must be installed on both the high-pressure and low-pressure sides of the system to recover refrigerant using the active method efficiently.
- The technician must help release trapped refrigerant from compressor oil during refrigerant recovery when using the active method of recovery on small appliances with nonoperating compressors.
- When recovering refrigerant from a small appliance with an inoperative compressor, a technician must heat and strike the compressor sharply with a rubber mallet and use a vacuum pump to draw the refrigerant out of the system into a non-pressurized container.

> *It is permissible to use a passive device on a domestic appliance for refrigerant recovery because it has less than 15 lb of refrigerant.*
>
> **Technical Fact**

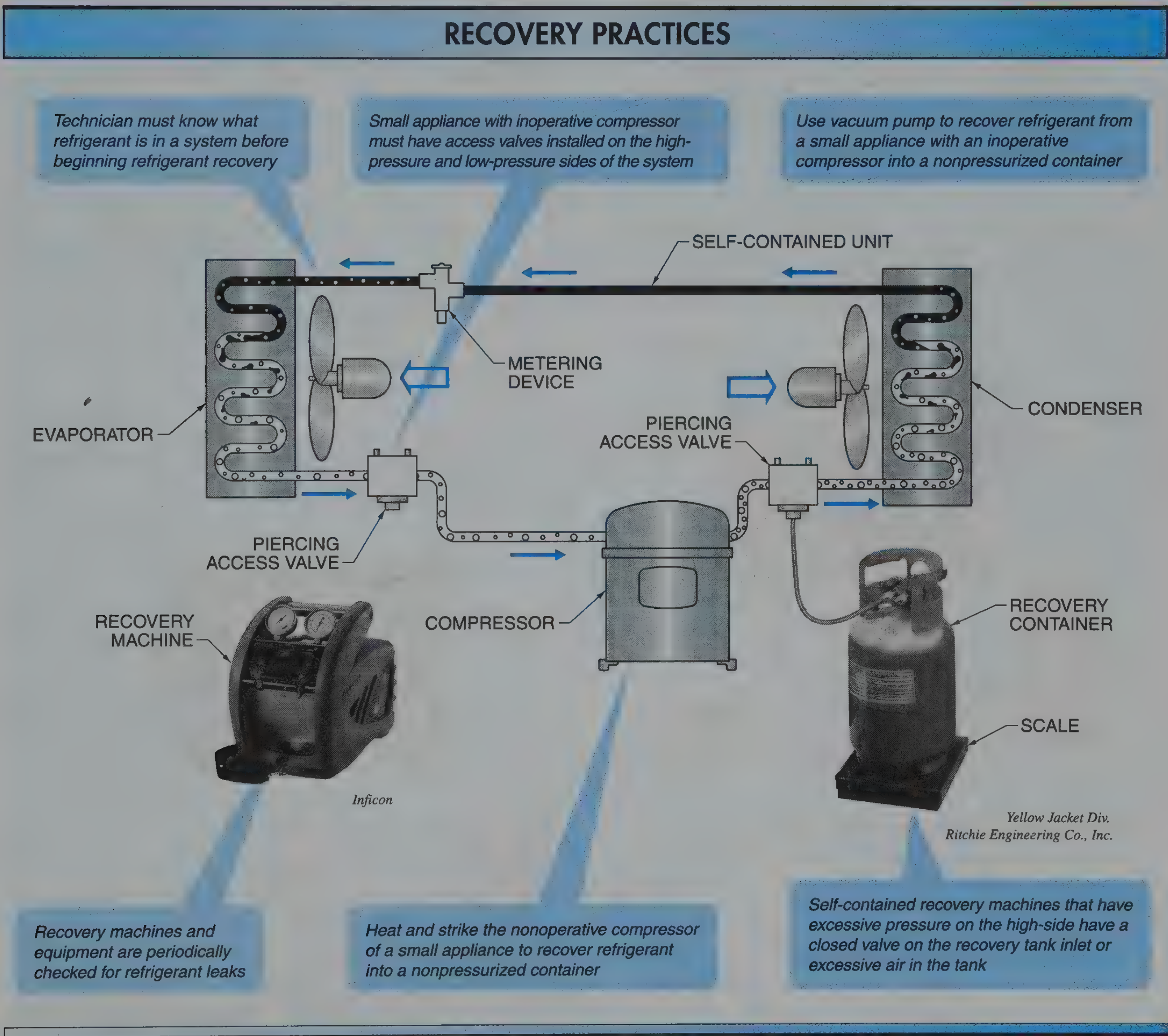
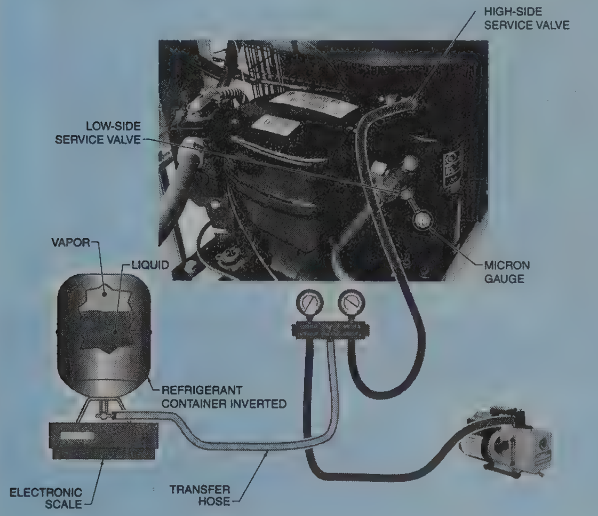


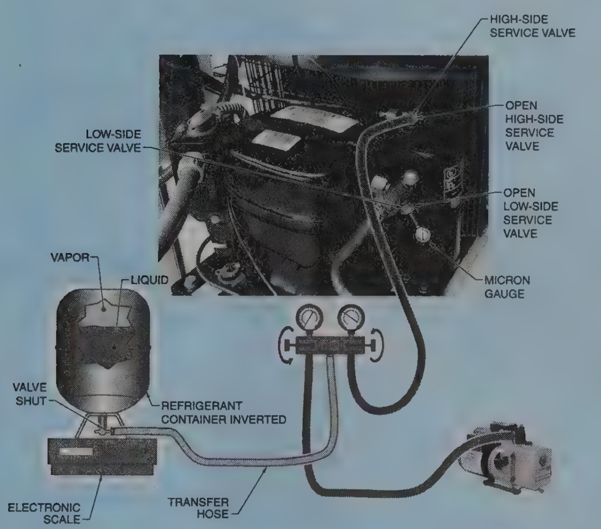
Figure 9-8. Small appliances may be opened for maintenance, service, or repair only if specific procedures are observed.

Charging Systems with Refrigerant (High-Pressure Side) Procedure

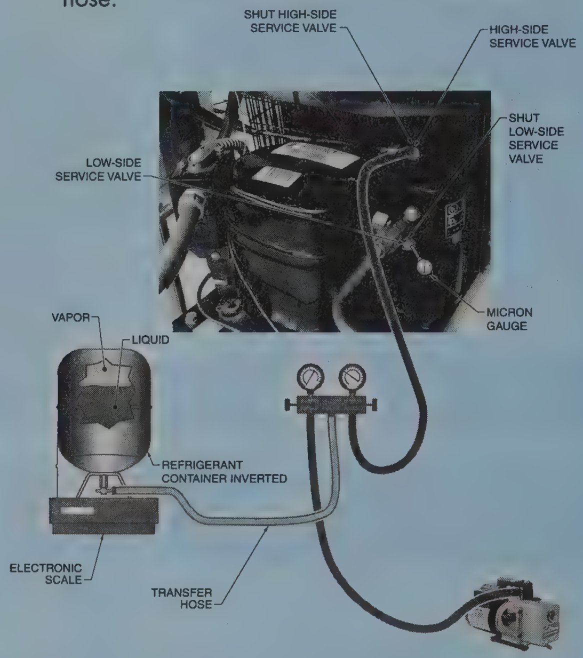
1. Recover refrigerant as required by EPA or ODSR regulations. Repair any leaks identified and pressure test system.
2. Install a micron gauge directly on the system low-side service valve.



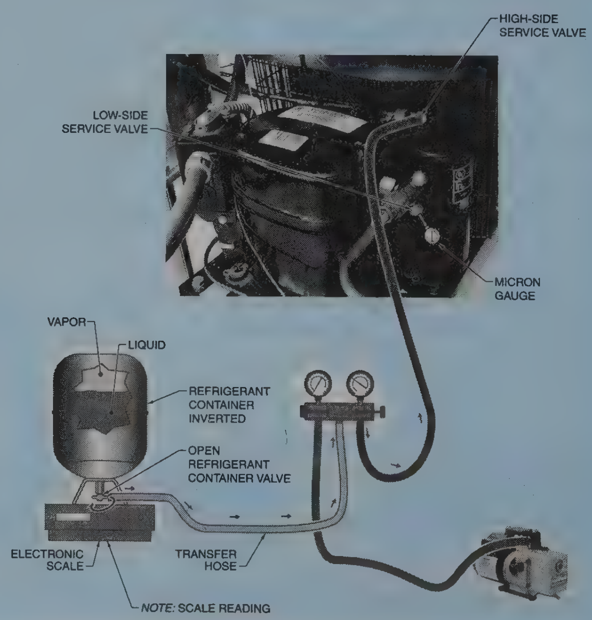
3. Open the red and blue manifold valves, and the high-side service valve and low-side service valve on the system. Keep the refrigerant container valve shut.



4. Evacuate the system to the proper level as required (500 microns). To check for proper evacuation level, close the blue service manifold valve (low pressure), loosen the blue hose connected to the vacuum pump before shutting off the pump to prevent the vacuum pump oil from being sucked out. Shut off the vacuum pump. Wait several minutes to see if the vacuum gauge shows that the vacuum level has not risen which means that there are no leaks and no moisture in system.
5. Shut off the low-side service valve isolating the micron gauge.
6. Shut off the high-side service valve closing off the red hose.



7. Note the scale reading and open the refrigerant cylinder valve allowing liquid refrigerant to flow into the yellow and red hoses up to the high side service valve.
8. Note the scale reading again. The difference is the weight of refrigerant that has entered the yellow and red hoses.



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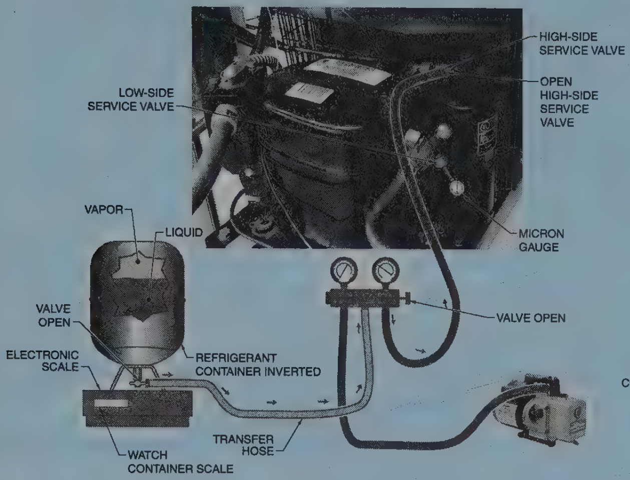
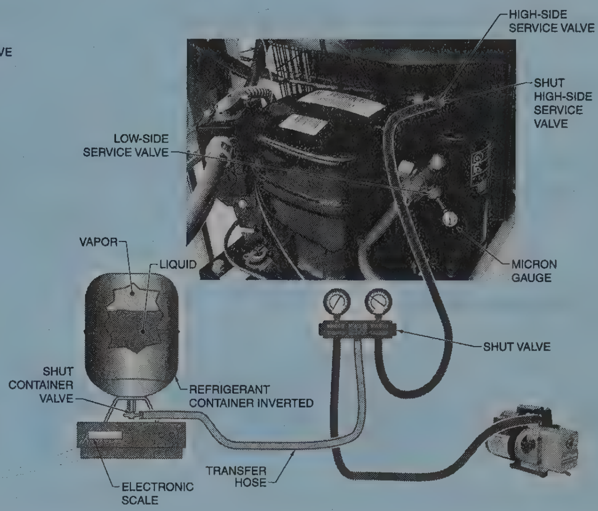
Charging Systems with Refrigerant (High-Pressure Side) Procedure *(continued)*

9. Open the high-side service valve and watch the container scale while leaving the container valve and the red manifold valve open.



10. Shut off the high-side service valve when the proper weight of refrigerant has flowed as indicated by the scale. The system now has the exact required amount of refrigerant by weight.

11. Shut off the refrigerant container valve and the manifold valves, and disconnect the hoses using the proper PPE (gloves) to prevent frostbite.



Discussion Questions

1. How does the EPA define small appliance?
2. Why must a small appliance have a service aperture?
3. Why must a solderless-type access valve be removed from a small appliance once repairs are completed?
4. How is small appliance servicing affected by EPA regulation changes?
5. Why do small appliances such as campers and recreational vehicles require refrigerant-specific recovery machines?
6. How must a technician prepare a refrigerant cylinder for shipment?
7. Why must technicians use recovery equipment that meets industry standards?
8. How are small appliances similar to other types of refrigeration systems?
9. When must a technician repair a leak in a small appliance?

10. How are accurate pressure readings of the refrigerant in a recovery cylinder taken?

11. Why are special procedures used to recover refrigerant from a nonpressurized small appliance?

12. Why must Schrader valve ports be capped during system operation?

13. Why are technicians servicing small appliances not always required to have self-contained recovery machines?

14. How is nitrogen used in small appliances?

15. Why must access valves be installed on the high-pressure and low-pressure sides of a small appliance for refrigerant recovery?

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REVIEW QUESTIONS

Name ______________________________ Date ______________

______________ 1. Small appliances ___.
- A. are field charged
- B. have semi-open compressors
- C. have no service aperture
- D. have 5 lb or less of refrigerant

______________ 2. Small appliances typically have a service port aperture that is entered using a ___.
- A. piercing access valve
- B. halide torch
- C. propane torch
- D. hacksaw

______________ 3. When system pressure of a small appliance is ___, the recovery process should not be started.
- A. 29.92 in. Hg
- B. 14.7 in. Hg abs
- C. 0 psi
- D. 0 psia

______________ 4. When EPA regulations are changed after a technician becomes certified, it is the responsibility of the ___ to comply with any changes to the law.
- A. air conditioning or refrigeration system owner
- B. recovery equipment owner
- C. technician
- D. EPA representative

______________ 5. All recovery equipment must be certified by an EPA-approved laboratory if it was manufactured after ___.
- A. September 7, 1991
- B. November 15, 1993
- C. July 18, 1999
- D. February 21, 2001

______________ 6. The Department of Transportation regulations require that the ___ of each refrigerant cylinder or shipping container be recorded on the shipping paperwork.
- A. weight
- B. age
- C. NFPA hazard signal
- D. health hazard

______________ 7. When a reclamation facility receives a container of mixed refrigerants, the reclamation facility ___ the refrigerant mixture.
- A. will store
- B. will separate the refrigerants, then process
- C. will charge more for processing
- D. may refuse to process

______ 8. The compressor used in small appliances is typically a ___ compressor or rotary compressor.

A. hermetically sealed reciprocating
B. centrifugal
C. screw
D. semi-open

______ 9. Because small appliances have a small amounts of refrigerant charge, the EPA states that small appliance leaks must be repaired ___.

A. within 30 days
B. within 120 days
C. according to submitted plan
D. whenever possible

______ 10. A storage cylinder of recovered R-12 refrigerant at a room temperature of 75°F, with no noncondensables, will have a pressure of approximately ___ psi.

A. 20
B. 45
C. 75
D. 110

______ 11. Accurate pressure readings of the refrigerant inside a recovery cylinder are important because the readings can indicate ___.

A. the size of the recovery container
B. whether the recovery container contains a dip tube
C. the refrigerant that is inside the container
D. whether excessive air and noncondensables are present

______ 12. The passive method of refrigerant recovery can only be used when less than ___ lb of refrigerant will be recovered.

A. 5
B. 15
C. 20
D. 50

______ 13. After recovering the entire refrigerant charge from a sealed small appliance system, ___ can be used to blow debris out of the system.

A. ammonia
B. nitrogen
C. compressed air
D. R-12

______ 14. When performing a system-dependent recovery process, a technician must ___ of the small appliance and recover refrigerant from the high-pressure side of the system.

A. run the compressor
B. disconnect the orifice
C. open the evaporator
D. open the metering valve

______ 15. When recovering refrigerant into a nonpressurized container from a small appliance with an inoperative compressor, a technician must ___ to remove the refrigerant from the system.

A. verify the recovery container is above the level of the system
B. open the system at the metering valve
C. heat the recovery container
D. heat and strike the compressor sharply

10

Type I (Small Appliances) Certification Test Questions

Twenty-five Type I (small appliances) questions are found on a Type I (small appliances) certification test. The information covered by the Type I questions includes refrigeration principles, safety, refrigerants, regulatory requirements, equipment disposal, and service practices.

Name ______________________________ Date ______________

______________ **1.** Small appliance recovery equipment manufactured on or after November 15,1993 must be certified to be capable of recovering ___% of the refrigerant when the compressor is not operating, or achieving a ___″ Hg vacuum under the conditions of ARI 740-1993.

A. 75; 10

B. 80; 4

C. 90; 4

D. 99; 10

______________ **2.** When recovering refrigerant from a system that experienced a compressor burnout, the technician must watch for signs of contamination in the refrigerant and oil because ___.

A. contaminants cannot be removed from the refrigerant and the refrigerant will have to be destroyed by the reclamation center

B. the system will have to be flushed out if contaminants are present

C. the contaminants will eat away the interior of a recovery cylinder

D. the contaminants will plug up the recovery equipment

______________ **3.** Effective August 12, 1993, persons using recovery equipment to recover refrigerant from a small appliance must certify to the EPA that they have equipment capable of ___ under conditions of ARI 740-1993.

A. removing 90% of the refrigerant when the compressor is operating or achieving a 10″ Hg vacuum

B. removing 80% of the refrigerant when the compressor is nonoperating or achieving a 4″ Hg vacuum

C. achieving a 27″ Hg vacuum

D. achieving a 15 Hg vacuum

_______________ **4.** Equipment manufactured after November 15, 1993 that is used to recover refrigerant from small appliances for the purpose of disposal must be able to recover ____, according to the standard.

A. 80% of the refrigerant with an operative compressor

B. 90% of the refrigerant with an inoperative compressor

C. 90% of the refrigerant with an operative compressor

D. 95% of the refrigerant regardless of whether the compressor is operative

_______________ **5.** If a large leak of refrigerant from a filled cylinder occurs in an enclosed area, and no self-contained breathing apparatus is available, then the technician must ____.

A. use butyl-lined gloves and try to stop the leak

B. use a leak detector to locate the leak and try to stop the leak

C. vacate and ventilate the spill area

D. vacate

_______________ **6.** Refrigerants such as R-12, R-22, and R-500 in large quantities can cause suffocation because the refrigerants ____.

A. have a very strong smell

B. are lighter than air and cause dizziness

C. are heavier than air and displace oxygen

D. combine with nitrogen to form CFCs

_______________ **7.** ____ is/are not a method or device presently used for monitoring the 80% fill level in a recovery tank.

A. Float devices

B. Scales

C. Sight glasses

D. Electronic control

_______________ **8.** When R-500 is recovered from an appliance, R-500 ____.

A. can be mixed with R-22 or R-12 refrigerants during the recovery process because R-500 is actually a mixture of the two refrigerants

B. can be mixed with R-12 but not R-22 during the recovery process

C. need not be recovered since R-500 is not one of the refrigerants covered by the Clean Air Act

D. must be recovered into a separate recovery vessel that is clearly marked to ensure that mixing of refrigerants does not occur

_______________ **9.** When using a system-dependent (passive) recovery process on a system with an operating compressor, technicians must run the compressor of the appliance ____.

A. on 240 V while recovering the refrigerant from the capillary tube

B. for several minutes, shut the compressor OFF, then recover the refrigerant from the high-pressure side of the system

C. to recover the refrigerant from the high-pressure side of the system

D. for several minutes, shut the compressor OFF, then recover the refrigerant from the low-pressure side of the system

_______________ **10.** Before shipping any used refrigerant in a cylinder, it is necessary to ____.

A. remove all labels

B. properly complete shipping paperwork

C. check the cylinders for leaks

D. check that the refrigerant container meets Department of Transportation standards

______ **11.** A refrigerant that can be used as a direct, "drop in" substitute for R-12 in a small appliance is ___.

A. R-134a

B. R-22

C. R-141b

D. R-153

______ **12.** Technicians must help release trapped refrigerant from the compressor oil during refrigerant recovery when ___.

A. using self-contained (active) recovery devices

B. using system-dependent (passive) recovery devices

C. using a system-dependent (passive) recovery device on small appliances with a nonoperating compressor

D. the refrigerant system has a low-pressure-side leak

______ **13.** Refrigerant recovery devices must be equipped with low-loss fittings, which are fittings that are used to connect the recovery device to an appliance and that ___.

A. prevent loss of refrigerant from connections

B. leak only small amounts of refrigerant during use

C. must be discarded after each use

D. are low-pressure and high-pressure oriented

______ **14.** When a household refrigerator compressor does not run, it is recommended that low- and high-pressure-side access valves be installed when recovering refrigerant from the system because ___.

A. appliance condensers have a high resistance to flow

B. it will stop refrigerant from being trapped in bypass

C. the compressor of the refrigerator can be damaged

D. it may be necessary to achieve required recovery efficiency

______ **15.** When a reclamation facility receives a cylinder of mixed refrigerant, the reclamation facility may ___.

A. process the refrigerant and resell it as a refrigerant blend

B. process the refrigerant into two or more reclaimed refrigerants

C. resell the refrigerant for reuse in its current state

D. refuse to process the refrigerant and return it at the owner's expense

______ **16.** At high temperatures, such as from open flames or glowing metal surfaces, R-12 and R-22 can decompose to form ___ gas.

A. hydrazine

B. phosgene

C. helium

D. chlorine

______ **17.** When installing a piercing access valve onto a sealed system, ___.

A. the fitting must be leak tested before proceeding with recovery

B. it is not necessary to leak test an access fitting

C. the fitting need not be leak tested until the total repair is completed

D. the system must be pressurized with dry nitrogen before leak testing can be attempted

______ **18.** Portable refillable tanks or containers used to ship CFC or HCFC refrigerants obtained with recovery equipment from small appliances must meet ___ standards.

A. Department of Transportation

B. Community Right-to-Know Act

C. Underwriters Laboratories

D. EPA

_______________ **19.** Since ___, technicians servicing small appliances are required to be certified in refrigerant recovery.

A. July 1, 1992
B. July 1, 1993
C. May 14, 1993
D. November 14, 1994

_______________ **20.** When attempting a system-dependent (passive) recovery process, both the high-pressure and low-pressure sides of the system must be accessed for refrigerant recovery when ___.

A. there is a leak in the system
B. the compressor operates normally
C. the compressor only runs at half speed
D. the compressor does not run

_______________ **21.** All small appliances must be equipped with an aperture or other device that is used when adding or removing refrigerant. For small appliances, the aperture typically is ___.

A. a straight piece of tubing that is entered using a piercing access valve
B. located 15″ below the compressor
C. installed at the factory with ¼″ diameter machine threads
D. not present because small appliances are exempt from this requirement.

_______________ **22.** Because small amounts of CFC and HCFC refrigerant have no odor, when a pungent odor is detected during refrigerant recovery or system repair, ___.

A. the refrigerant should not be recovered
B. a compressor burnout has likely occurred
C. refrigerants have been mixed
D. the refrigerant must be reclaimed

_______________ **23.** ___ refrigerant used in refrigerators built before 1950 should not be recovered with current recovery machines.

A. Dichlorodifluoromethane
B. Tetrafluoroethane
C. Monochlorodifluoromethane
D. Methyl formate

_______________ **24.** When EPA regulations change after a technician becomes certified, ___.

A. the technician must take a 4 hr recertification class
B. it is the responsibility of the technician to comply with any changes in the law
C. a new certification test must be taken to be recertified
D. the EPA contacts technicians with update notices

_______________ **25.** Small appliance recovery equipment manufactured on or after November 15,1993 must be certified to be capable of recovering ___% of the refrigerant when the compressor is operating, or achieving a ___″ Hg vacuum under the conditions of ARI 740-1993.

A. 75; 10
B. 80; 4
C. 90; 4
D. 99; 10

_______________ **26.** EPA rules require capturing 80% of the refrigerant from a small appliance that has a nonoperating compressor if technicians are using a ___.

A. piston pump recovery machine
B. recovery machine manufactured after 2004
C. dry vacuum pump
D. self-contained (active) process

______________ **27.** When ___, an excessive pressure condition on the high-pressure side of a self-contained (active) recovery device will exist.

A. a system has had a compressor burnout
B. there is excessive vacuum in the recovery container
C. the recovery container outlet valve has not been opened
D. the recovery container inlet valve has not been opened

______________ **28.** A standard vacuum pump can be used ___.

A. alone as a self-contained (active) recovery device
B. as a recovery device in combination with a nonpressurized container
C. alone as a substitute for any recovery device
D. alone as a system-dependent (passive) recovery device

______________ **29.** Packaged terminal air conditioners (PTACs) may be serviced by a type I technician only if the PTAC ___.

A. contains 5 lb or less of refrigerant
B. contains 15 lb or less of refrigerant
C. contains 25 lb or less of refrigerant
D. is charged with R-12

______________ **30.** A small appliance, according to EPA regulations, ___.

A. is manufactured, charged with less than 5 lb of refrigerant, and hermetically sealed in a factory
B. operates at pressures above 750 psi
C. is a system with a compressor under ½ hp
D. is a system with an evaporator under 160 in^2

______________ **31.** A full storage cylinder of recovered R-12 at normal room temperature (about 75°F), with no non-condensables present, should be pressurized to ___ psi.

A. 30
B. 75
C. 150
D. 200

______________ **32.** Wearing ___ is a recommended safe work practice.

A. safety boots to protect feet from flash freezing leaks
B. a respirator when working with any refrigerant
C. a heavy canvas jacket to protect the chest from unwanted sprays
D. safety glasses or goggles when working with any compressed gas

______________ **33.** A reason to obtain an accurate pressure reading of refrigerant inside a recovery cylinder is that the pressure reading can indicate ___.

A. the type of refrigerant in the container
B. whether the refrigerant has been contaminated
C. whether the refrigerant is a blend
D. whether the refrigerant has broken down

______________ **34.** A system-dependent (passive) recovery process for small appliances ___.

A. never needs the use of a pump or heat to recover refrigerant
B. must use a pressure-relief device when recovering refrigerant
C. can capture refrigerant into a nonpressurized container
D. can only be performed on a system with a nonoperating compressor

________ **35.** When using nitrogen to pressurize a sealed refrigeration system, the nitrogen tank must be equipped with a ____.

A. regulator
B. float fill sensor
C. gray body and red top
D. relief valve

________ **36.** When filling a cylinder with a graduated charging device, refrigerant that is vented off the top of the cylinder ____.

A. need not be recovered
B. must be recovered
C. is considered a de minimis release
D. must be reported to the EPA

________ **37.** When using recovery cylinders and equipment with Schrader valves, it is critical to ____.

A. set the relief valves properly
B. back the stem off the seat ¼ turn
C. clean the valves annually
D. cap the Schrader valve ports to prevent accidental damage to the valve core

________ **38.** With high temperatures and contact with metals, R-12 and R-22 can decompose to form ____ and ____ acids.

A. boric; chromic
B. sulfuric; phosphoric
C. hydrochloric; hydrofluoric
D. methylchloric; sulfuric

________ **39.** Recovery equipment used during the maintenance, service, or repair of small appliances must be certified by an EPA-approved laboratory if manufactured after ____.

A. July 1, 1992
B. July 1, 1993
C. May 13, 1993
D. November 15, 1993

________ **40.** When recovering refrigerant into a nonpressurized container from a refrigerator with an inoperative compressor, it is ____.

A. necessary to recover as much refrigerant as will naturally flow out of the system
B. not necessary to recover since the refrigerant is probably contaminated
C. necessary to chase the refrigerant from the oil with pressurized dry nitrogen
D. necessary to heat and strike the compressor sharply several times while using a vacuum pump

________ **41.** After recovering refrigerant from a sealed system and using nitrogen to pressurize or blow debris out of the system, the nitrogen ____.

A. must be recovered
B. may be vented if not contaminated
C. must be recovered into a separate container
D. can only be used if mixed with ammonia

________ **42.** If a sealed system with an operating compressor has a completely restricted capillary tube metering device, ____ side of the system, is/are required to evacuate the refrigerant from the system.

A. two access valves, one on the high-pressure and one on the low-pressure
B. only one access valve, on the low-pressure
C. only one access valve, on the high-pressure
D. two piercing access valves on the low-pressure

______ **43.** The Department of Transportation Regulations–49 CFR, require that the ___ be recorded on the shipping paper for hazard class 2.2, nonflammable compressed gases.

A. weight of each cylinder
B. total cubic feet of each gas
C. number of cylinders of each gas
D. total weight of all cylinders

______ **44.** As of November 14, 1994, the sale of CFC and HCFC refrigerants was ___.

A. banned
B. limited by law to equipment owners
C. allowed only if there is proof of need
D. restricted to technicians certified in refrigerant recovery

______ **45.** When servicing a small appliance for leak repair, it is ___.

A. mandatory to repair the leak within 30 days
B. mandatory to repair the leak only when 35% of the charge escapes within a 12 month period
C. not mandatory to repair the leak, but do so whenever possible
D. mandatory to repair the leak only when 35% of the charge escapes within a 6 month period

______ **46.** Refrigerant inside a recovery cylinder must be allowed to stabilize to room temperature ___.

A. to prevent safety valves from purging refrigerant
B. because this is a quick-check method of determining refrigerant level inside the tank
C. because comparisons to a pressure-temperature chart can only be made if both pressure and temperature are stable and known
D. because the recovery cylinder could explode if temperature changes too quickly

______ **47.** A full storage cylinder of recovered R-22 at normal room temperature (about 75°F), with no non-condensables present, should be pressurized to ___ psi.

A. 130
B. 175
C. 200
D. 250

______ **48.** It is generally recommended that piercing-type valves be used on ___ tubing materials.

A. copper and aluminum
B. plastics
C. steel
D. carbon and stainless steel

______ **49.** ___ and ___ refrigerants can be mixed.

A. R-11; R-12
B. R-12; R-134a
C. R-12; R-22
D. R-22; R-115

______ **50.** To speed up the recovery process and ensure that all refrigerant has been removed from a frost-free refrigerator, ___.

A. cool the compressor to force liquid out of the high-pressure side
B. heat the recovery cylinder to vaporize liquid refrigerant
C. turn the defrost heater of the system ON to vaporize any trapped liquid
D. pack ice around the evaporator to ensure maximum liquid is available

_______________ 51. When a technician checks system pressures to determine the performance of a refrigeration system, it is good practice to ___.

A. release a small amount of refrigerant to check for contamination
B. use equipment such as hand valves and self-sealing hoses to minimize any release
C. recover refrigerant and recharge to specifications, even if no repairs are needed
D. use recovery equipment to gain access to the system during testing

_______________ 52. Technicians receiving a passing grade on the small appliance examination are certified to recover refrigerant during the maintenance, service, or repair of ___.

A. packaged terminal air conditioners (PTACs) with 5 lb or less of refrigerant
B. small central air conditioning systems with 10 lb or less of refrigerant
C. low-pressure equipment
D. motor vehicle air conditioning equipment

_______________ 53. When solderless-type piercing valves are used, the valves must not remain installed on refrigeration systems after completion of repairs because solderless-type piercing valves ___.

A. are too expensive to remain on every product
B. tend to leak over time
C. become loose and break the core
D. create a weak spot in the tubing

_______________ 54. A person recovering refrigerant during maintenance, service, or repair of small appliances must be certified as a ___ technician.

A. Type II
B. Type III
C. Type I or universal
D. core

_______________ 55. After installing and opening a piercing access valve, if system pressure is ___ psi, do not begin the refrigerant recovery procedure.

A. 0
B. 30
C. 50
D. 75

_______________ 56. The maximum allowable factory charge of refrigerant for type I appliances is ___ lb.

A. 3
B. 5
C. 10
D. 15

_______________ 57. Before beginning a refrigerant recovery procedure, a technician must ___.

A. allow the appliance to stabilize to room temperature
B. know the type of refrigerant that is in the system
C. remove the appliance to an outdoor location
D. disconnect the appliance from its power source

_______________ 58. It is permissible to use the passive recovery method for refrigerant recovery on a ___.

A. centrifugal air conditioner
B. reciprocating liquid chiller
C. single-compressor, large commercial walk-in freezer
D. domestic refrigerator

_______________ **59.** ___ is a refrigerant that must be recovered with equipment currently regulated by the equipment certification requirements of the EPA under Section 608.

A. Sulfur dioxide
B. Methyl chloride
C. Methyl formate
D. R-12

_______________ **60.** When used as a refrigerant for small appliances such as campers or recreational vehicles, ___ must be recovered with refrigerant-specific approved recovery machines.

A. sulfur dioxide
B. methyl chloride
C. methyl formate and chlorine
D. ammonia and hydrogen

_______________ **61.** A(n) ___ is not a type I appliance.

A. MVAC-like system that holds 3 lb of R-12
B. water cooler that holds 13 oz of R-12
C. food freezer that holds 22 oz of R-22
D. dehumidifier with 7 oz of R-500

_______________ **62.** Any technician that opens an appliance for maintenance, service, or repair must have at least one self-contained recovery machine available at their place of business, except when recovering refrigerant passively from ___ appliances.

A. small
B. low-pressure
C. high-pressure
D. very high-pressure

_______________ **63.** Checking ___ is a maintenance practice that must be performed on a regular basis.

A. recovery equipment for vacuum leaks
B. recovery equipment for refrigerant leaks
C. amperage draw of recovery equipment
D. vacuum pumps

_______________ **64.** To charge a small appliance with liquid R-12, the refrigerant cylinder should be ___.

A. inverted
B. upright
C. horizontal
D. manufactured with a dip tube

_______________ **65.** When a reclamation facility receives a container of mixed refrigerants, the reclamation facility will ___ the refrigerant mixture.

A. store
B. separate the refrigerants, then process
C. charge more for processing
D. refuse to process

11 Type II (High-Pressure Equipment)

Type II (high-pressure equipment) is larger than small appliances, but smaller than low-pressure equipment. Packaged terminal air conditioning units, refrigeration coolers, and split-system air conditioners are examples of high-pressure equipment. The amount and type of refrigerant charge found inside the equipment require components unique to high-pressure systems.

TYPE II (HIGH-PRESSURE EQUIPMENT)

Refrigeration machines, packaged terminal air conditioning (PTAC) units, and split-system air conditioning units (using R-22) are examples of high-pressure equipment typically found in the Type II category. Any equipment that contains over 5 lb of refrigerant and is not categorized as low-pressure falls into the Type II (high-pressure equipment) category.

The disposal of refrigerants and the servicing of high-pressure chillers, commercial refrigeration units, commercial and residential air conditioning, and heat pumps require that technicians be certified under the high-pressure equipment (Type II) certification.

HIGH-PRESSURE REFRIGERANTS

High-pressure equipment uses refrigerants with boiling points between -58°F (-50°C) and 50°F (10°C) at atmospheric pressure. Refrigerants such as R-12, R-22, R-114, R-134a, R-500, and R-502 are high-pressure refrigerants. Very high-pressure equipment uses refrigerants with boiling points below -58°F (-50°C) at atmospheric pressure. Refrigerants such as R-13, R-410A, and R-503 are very high-pressure refrigerants. The easiest way to determine the type of refrigerant used in a high-pressure system is checking the system nameplate. **See Figure 11-1.**

Refrigerants that are classified as A1 refrigerants are considered safe due to their low toxicity and flammability ratings. Examples of A1 refrigerants are CFC-11, CFC-12, and HFC-134a.

▶ Technical Fact

REGULATORY REQUIREMENTS

The EPA requires that all appliances containing more than 50 lb of refrigerant (except for commercial and industrial process refrigeration) be repaired when the leak rate of the appliance exceeds 15% of the charge per year. Leaking commercial and industrial process refrigeration must be repaired when the leak rate exceeds 35% of the charge per year.

The evaporation temperature for R-12 is −21°F at 14.7 psia, R-22 is −41°F at 14.7 psia, and R-134a is −15°F at 14.7 psia.

▶ Technical Fact

ASHRAE Standard 15 requires that all equipment rooms with refrigerants be equipped with an oxygen deprivation sensor.

▶ Technical Fact

SYSTEM NAMEPLATES

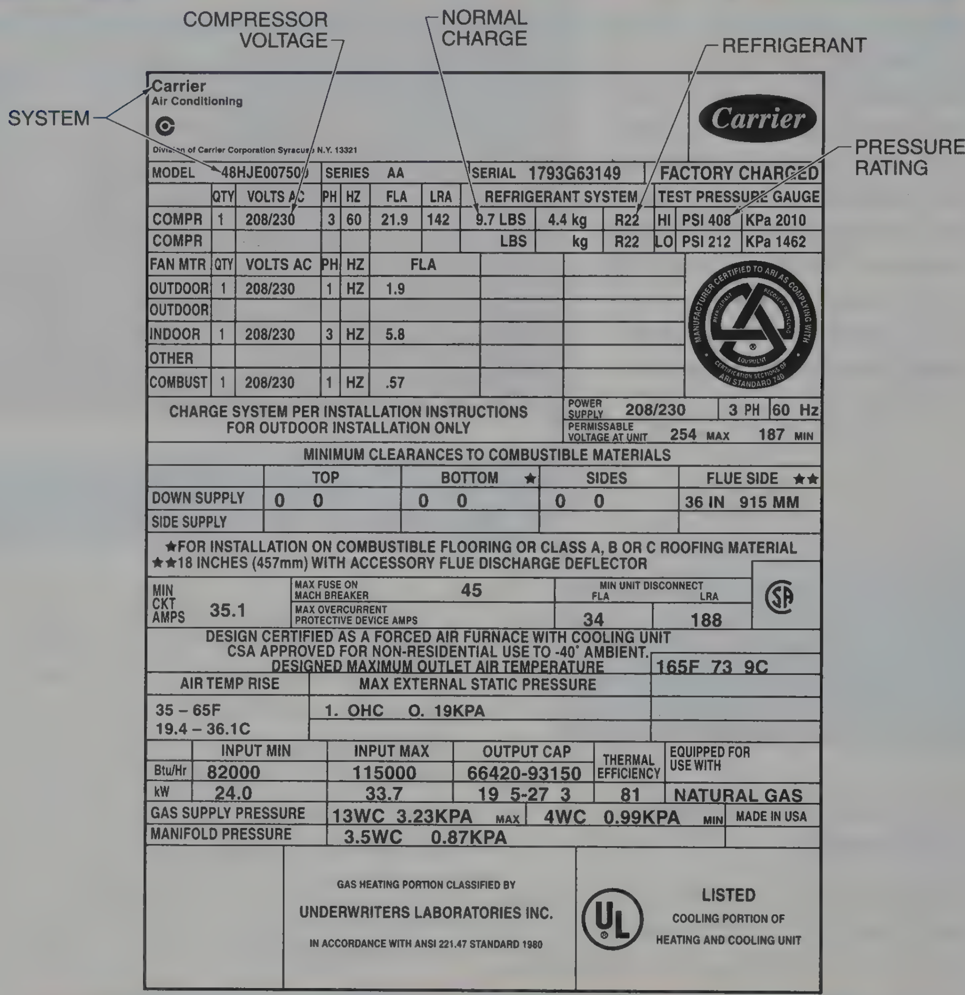


Figure 11-1. System nameplates provide the technician with information such as type of refrigerant, type of compressor, maximum test pressure, and normal charge.

The EPA considers the replacement of any high-pressure system major component a major repair.

Technical Fact

Technicians must have the ability to interpret pressure/temperature charts. When an R-12 system at room temperature (72°F) is idle, the system is at approximately 74 psi.

Technical Fact

The only time appliances containing CFC refrigerants are allowed to be evacuated only to atmospheric pressure is when leaks in the appliance make evacuation to the prescribed vacuum levels unattainable.

Phase-Out of HCFC-22

HCFCs such as R-22 are being phased out according to the following schedule:

- As of January 1, 2010, a ban was placed on the production, import, and use of HCFC-22 refrigerant except for ongoing servicing needs of existing equipment.
- As of January 1, 2020, a ban will be placed on the remaining production and import of HCFC-22 refrigerants.
- After 2020, the servicing of systems that use R-22 or blends containing HCFC-22 will rely on recovered or stockpiled quantities. It is difficult to predict when these supplies will run out. Supplies may be available until almost all equipment containing R-22 or any HCFC is retired. However, supplies will be limited and costs of HCFC will rise.

HIGH-PRESSURE SYSTEM COMPONENTS

High-pressure system components typically include reciprocating, screw, or scroll compressors. High-pressure appliance compressors have hermetically sealed, semi-hermetic, or open housings. Condensers used in high-pressure systems can be air-cooled or water-cooled. Air-cooled condensers are of a tube-and-fin design, while water-cooled condensers are of a coil-in-shell or tube-in-shell design.

The metering device typically used on high-pressure appliances is a thermostatic expansion valve. The evaporator can be dry expansion or flooded. The evaporator will be of fin-and-tube, coil-in-shell, or tube-in-shell design.

> *Pressure relief valves must not be installed in series.*
>
> ▶ Technical Fact

High-Pressure System Accessories

High-pressure systems typically include filter/dryers, moisture indicators, thermal expansion valves, receivers, and accumulators. **See Figure 11-2.** When a high-pressure refrigeration system utilizes a thermal expansion valve, the component directly following the condenser on the high-pressure side of the system is the receiver. The refrigerant leaving the receiver of a high-pressure refrigeration system is in a high-pressure liquid state. When a system is opened for service, the filter/dryer should be replaced. A moisture-indicator sight glass is located after the receiver and is used for checking the moisture content and refrigerant charge of a system (ice accumulating on a sight glass can be removed with an alcohol spray). The component directly following the evaporator and close to the compressor of a high-pressure refrigeration system is the accumulator.

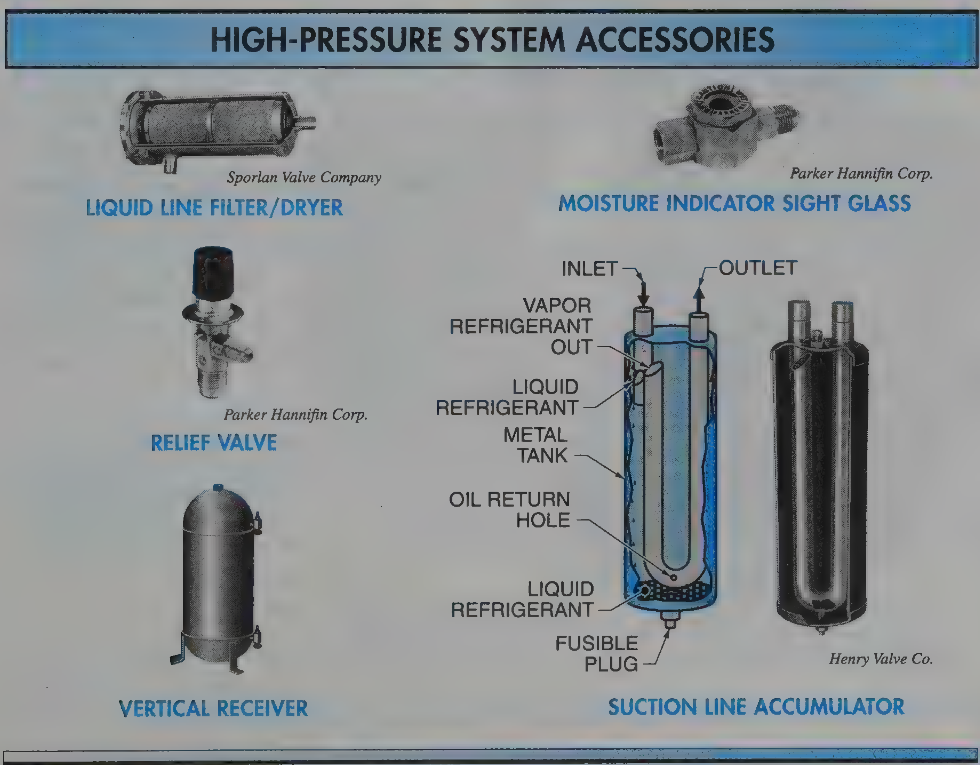


Figure 11-2. High-pressure refrigeration systems typically include accessories, such as filter/dryers, moisture indicators, sight glasses, pressure relief valves, receivers, and accumulators to assist system operation.

Recovery and Recycling Machines

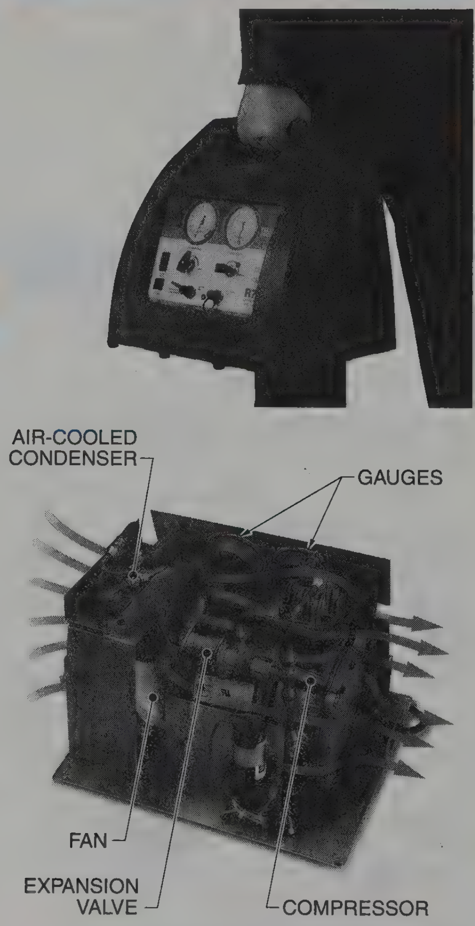
Recovery and recycling machines have the same components as a refrigeration system. **See Figure 11-3.** Before using a recovery machine to remove a charge from a high-pressure system, the recovery unit oil level and service valve positions must be checked. The primary water source for the water-cooled condensing coil of a recovery machine is the local municipal water supply. The water flow rate to the condensing coil of a recovery machine must be verified before the recovery machine is turned ON.

Typically, the most common maintenance task that must be performed on refrigerant recovery and recycling machines is the changing of the oil and filters. Special procedures are required with recovery and recycling machines that handle more than one refrigerant. For example, if a recovery and recycling machine contains R-502 refrigerant from a previous refrigerant recovery and the technician must recover refrigerant from a system containing R-22 refrigerant, the technician must recover as much of the R-502 from the recovery unit as possible by evacuation, then change filters on the recovery unit and recover the R-22 refrigerant.

> *All high-pressure systems must be protected by a relief device.*
>
> **Technical Fact**

> *Recovery and recycling equipment manufactured after November 15, 1993 must meet the following requirements:*
> - *be tested by an EPA-approved third party*
> - *be equipped with low-loss fittings*
> - *meet vacuum standards that are more stringent than those prior to November 15, 1993*
>
> **Technical Fact**

RECOVERY MACHINE COMPONENTS



Yellow Jacket Div., Ritchie Engineering Co., Inc.

Figure 11-3. High-pressure system recovery and recycling machines are made up of the same components as a refrigeration system.

> *Technicians must evacuate the recovery unit/receiver before removing a charge from a system.*
>
> **Technical Fact**

High-Pressure System Refrigerant Recovery Precautions

Technicians must never mix refrigerants in any manner when recovering refrigerants into storage containers. Any kind of contamination must be avoided at all cost. When recovering high-pressure refrigerants, the following precautions must be observed to protect equipment from damage:

- Never recover refrigerant with a recovery machine while the system compressor is operating. A hermetically sealed compressor has the potential to overheat when deep vacuums (500 microns) are being created because the electric motor relies on the flow of refrigerant through the compressor for cooling. As the vacuum is deepened,

there is less refrigerant remaining in the system to cool the compressor motor. **See Figure 11-4.**

- Recovery and recycling machines that contain R-502 refrigerant and that must be used to recover refrigerant from a system with R-22 refrigerant require the technician to recover as much of the R-502 refrigerant from the recovery machine as possible, then change filters and evacuate the recovery machine.
- Recovered refrigerant may contain acids, moisture, and lubricating oils. If recovered refrigerant is not damaged or contaminated, the refrigerant can be charged back into the same system or another system under the same ownership once system repairs are completed.
- System-dependent (passive) refrigerant recovery cannot be used when a high-pressure appliance contains over 15 lb of high-pressure refrigerant.

A storage cylinder of R-12 refrigerant at room temperature (70°F) has a pressure of 70 psi.

▶ Technical Fact

HCFC refrigerants are being replaced with HFC refrigerants. When servicing a residential split system that provides comfort air conditioning, R-22 refrigerant can be expected to exist in the system. Newer systems will have HFC-407 or HFC-410 refrigerants.

▶ Technical Fact

REFRIGERANT RECOVERY PRECAUTIONS

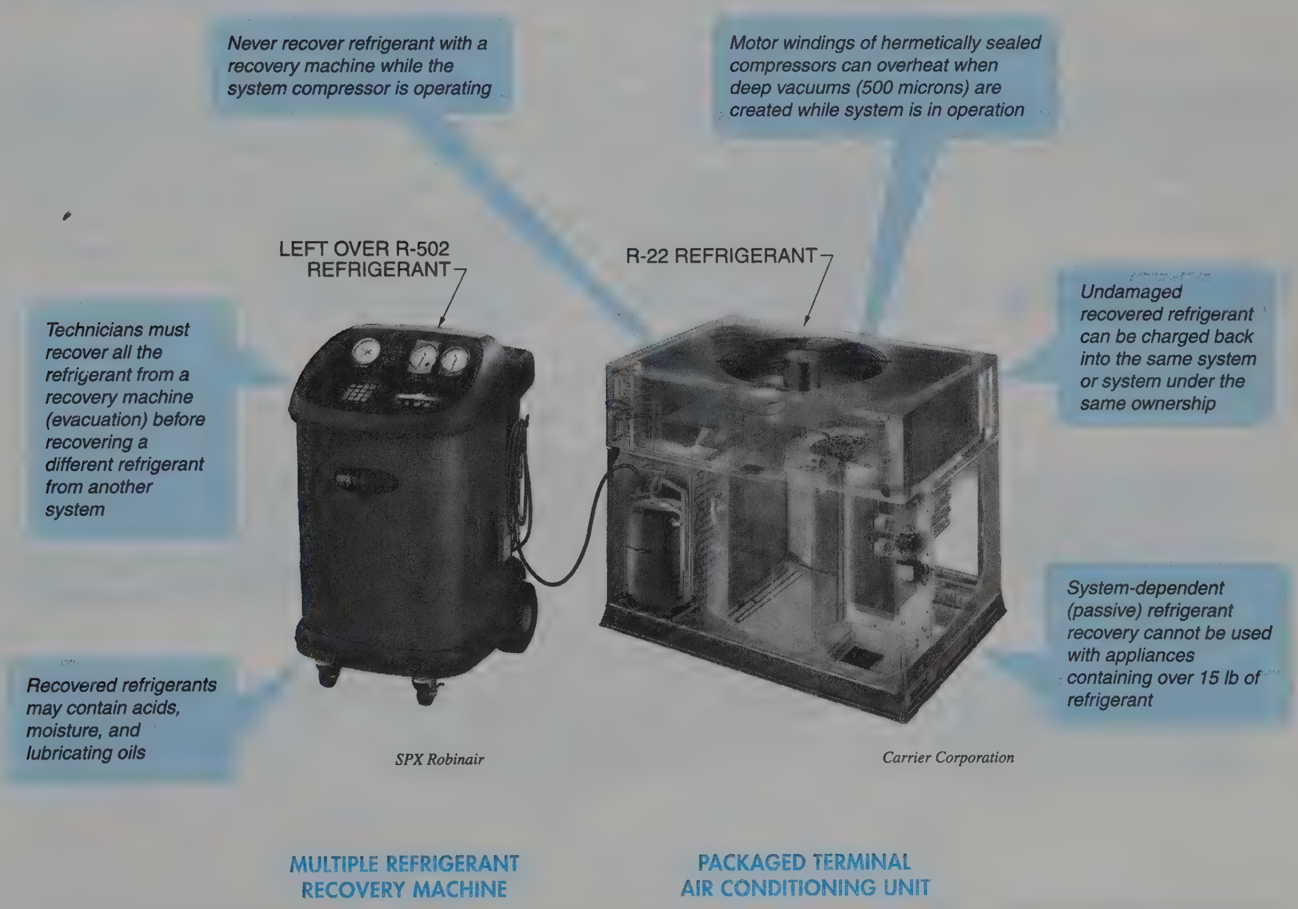


Figure 11-4. Special precautions must be followed when recovering refrigerant from a high-pressure system.

SERVICE PRACTICES

Service practices for high-pressure equipment include refrigerant recovery, evacuation, charging, and system leak testing. When performing service to a high-pressure system, the technician must remember the importance of protecting the environment, equipment, and, most of all, people.

Pressure decreases in a high-pressure system that has a leak, causing the evaporator to starve and superheat to increase. Leak test high-pressure systems before charging.

▶ Technical Fact

High-Pressure System Leak Testing

Some high-pressure refrigeration systems use open-type compressors. Open-type compressor high-pressure systems that have not been used for several months can have a leaking compressor shaft seal. High-pressure systems should be leak tested prior to charging or recharging any refrigerants into the system. **See Figure 11-5.**

Replacement of any major system component, such as an evaporator coil, is considered to be a major repair under EPA regulations.

▶ Technical Fact

When inspecting a hermetically sealed compressor system that is known to have a leak, technicians should look for traces of refrigerant oil. Testing with soap bubbles is a typical method used for pinpointing refrigerant leaks in high-pressure systems. Checking for proper superheat is another way to find a leak. A low refrigerant charge resulting from leaks in the system starves the evaporator of refrigerant, increasing the superheat. Excessive superheat can be used as an indicator of a leak in a high-pressure system.

The vacuum method of leak detection is also used on high-pressure systems. When creating a deep vacuum (500 microns) on a high-pressure refrigeration system with a hermetically sealed compressor, the compressor motor windings can be damaged if the compressor motor is energized. Because of the possibility of damage to the motor, the compressor of a high-pressure system cannot be operated during system evacuation.

Nonpressurized systems can also be pressurized to check for leaks. A refrigerant trace gas is used with nitrogen to pressurize a high-pressure system to locate a leak using leak detection devices. When a refrigerant trace gas must be used to identify a leak, HCFC-22 should be used. A refrigerant trace gas is used only when the leak detecting method being used cannot detect nitrogen. High-pressure systems are leak checked with an inert gas such as pressurized nitrogen.

High-Pressure System R-134a Refrigerant Recovery

Recovering R-134a refrigerant requires special precautions. Recovery equipment recovering R-134a refrigerant must use special hoses, gauges, vacuum pumps, oil, and containers designed only for R-134a refrigerants.

High-pressure systems containing CFC refrigerants need to be evacuated only to atmospheric pressure when leaks in the system make evacuation to the prescribed level unattainable. R-134a refrigerant charged systems are leak checked with pressurized nitrogen.

▶ Technical Fact

Increasing Speed of Refrigerant Recovery in a High-Pressure System

There are certain techniques and procedures that will decrease recovery time for refrigerant from a high-pressure system. Technicians want the recovery to be as quick as possible. When there is flow of any kind, the flow

rate is always the greatest where the pressure or temperature difference is the greatest. The refrigerant recovery time also decreases when recovering liquid refrigerant as opposed to refrigerant vapor.

- Removing the refrigerant charge from a system is accomplished more quickly by packing the recovery container (cylinder) in ice. **See Figure 11-6.**
- Before transferring refrigerant to an empty cylinder, the empty cylinder must be evacuated.
- Technicians can save time recovering refrigerant from a system by removing as much of the refrigerant as possible in the liquid state. After the liquid refrigerant has been recovered from a high-pressure appliance, any refrigerant vapor is condensed by the recovery machine and recovered.
- Recovering refrigerant from a system in a vapor state minimizes the loss of refrigerant oil, even though recovering vapor is slower.

High-Pressure System Refrigerant Recovery Techniques

When recovering high-pressure refrigerant, technicians must remember to always recover the refrigerant from the lowest point of the system to have gravity aid in the recovery. The technician must verify that parts of the system are isolated (when necessary) when recovering refrigerant, and must recover the refrigerant that may be left in the receiver of the system.

EPA regulations require that all appliances containing more than 50 lb of refrigerant (except for commercial and industrial process refrigerant) be repaired when the leak rate exceeds 15% of the charge per year.

Technical Fact

HIGH-PRESSURE SYSTEM LEAK TESTING

DISPLAY COOLER REFRIGERANT UNIT

Figure 11-5. Leak testing in a high-pressure system is accomplished by various methods, but soap bubbles are commonly used to pinpoint a leak.

INCREASING REFRIGERANT RECOVERY SPEED

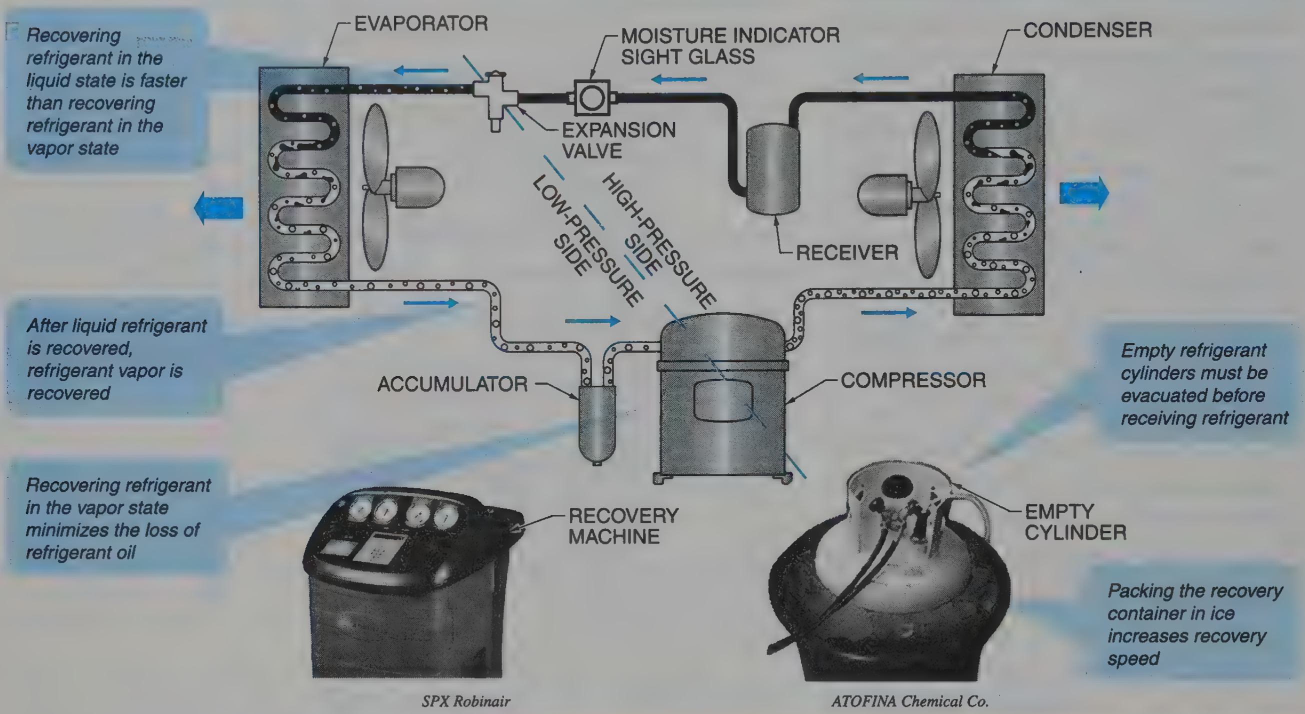


Figure 11-6. Increasing the speed of refrigerant recovery from a high-pressure system saves a technician time and money.

A refrigerant monitor is required for all refrigerants in a mechanical room under ASHRAE Standard 15.

Technical Fact

- When a high-pressure air conditioning system has the air-cooled condenser on the roof of the building and the evaporator on the first floor, the system is considered a split system. Refrigerant recovery must start at the liquid line (with one hose connected to the liquid line) where the liquid line enters the evaporator, because the liquid line is the lowest access point in the system. **See Figure 11-7.**
- Refrigerant must be removed from the outlet of the condenser when the condenser is below the receiver of the system.
- Refrigerant cannot be recovered without isolating a parallel compressor system because of an open equalization connection.
- When an operating high-pressure system has a receiver or storage tank and the system must be opened for service, refrigerant must be recovered from the receiver.

High-Pressure System Evacuation

Evacuation is performed to remove noncondensables and particles that should not be mixed with the refrigerant of a high-pressure system. Refrigerant recovery occurs before system evacuation. Once repairs are completed on a high-pressure system, the system is leak tested, then evacuated and charged with refrigerant. When a new high-pressure system is assembled (built up), planned evacuation of the system to prescribed levels is the first service procedure performed. **See Figure 11-8.** Very high-pressure appliances are brought to 0 psi when the recovery equipment manufacture date is either before or after November 15, 1993.

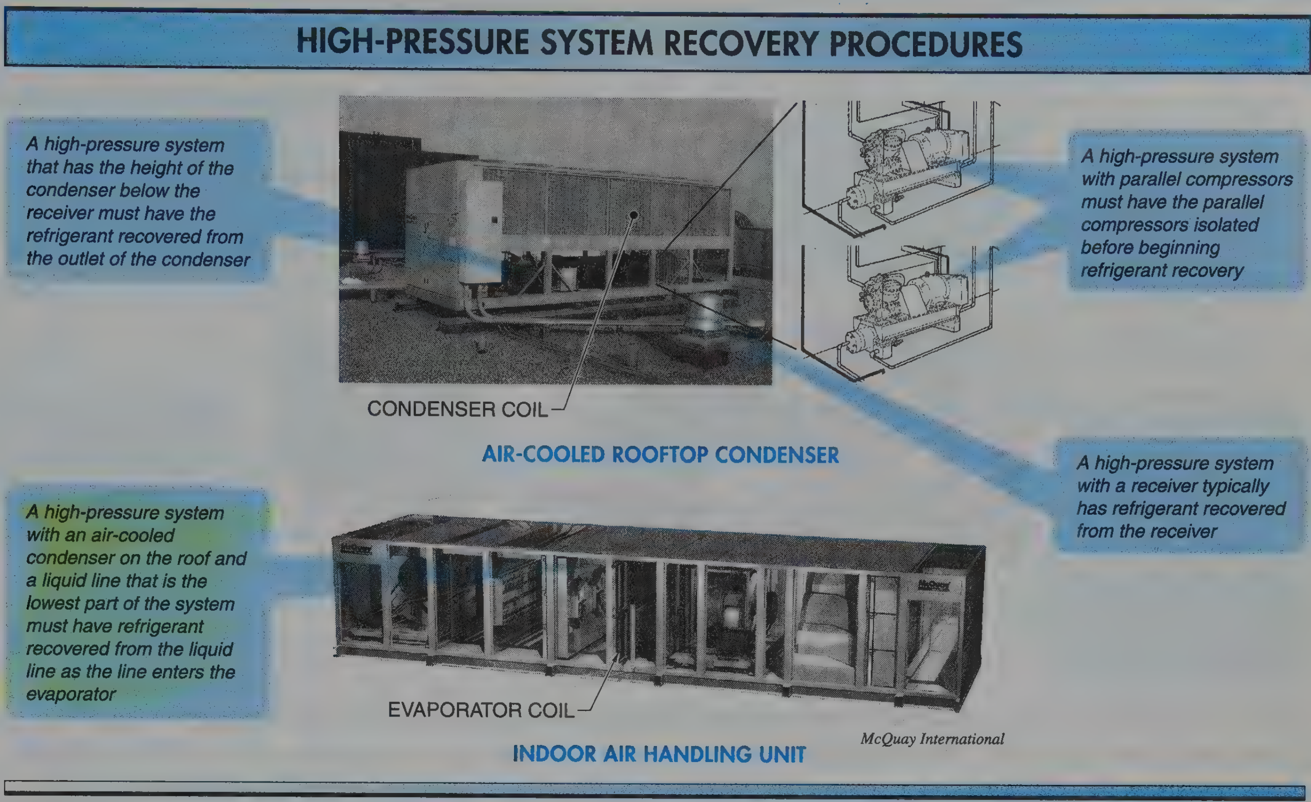


Figure 11-7. The procedure used for recovering refrigerant from a high-pressure system depends on which component is the lowest component in the system.

ARI 740—PLANNED HIGH-PRESSURE EQUIPMENT EVACUATION

Type of Appliance*	Equipment Manufactured before November 15, 1993	Equipment Manufactured on or after November 15, 1993
HCFC-22 appliance normally containing less than 200 lb of refrigerant	0 psi	0 psi
HCFC-22 appliance normally contains 200 lb or more of refrigerant	4″ Hg	10″ Hg
Other high-pressure appliance normally containing less than 200 lb of refrigerant	4″ Hg	10″ Hg
Other high-pressure appliance normally containing 200 lb or more of refrigerant	4″ Hg	15″ Hg

*or isolated component of high-pressure system

Figure 11-8. When a new high-pressure system is installed, evacuation of the system to prescribed levels is the first service procedure performed.

- After installation of a field-piped split system, the system must be evacuated before any other procedures are performed. **See Figure 11-9.**
- When evacuating a vapor compression system, the vacuum pump should be in good working order and capable of creating a vacuum of 500 microns.
- Never energize the compressor of a high-pressure system while the system is being evacuated.

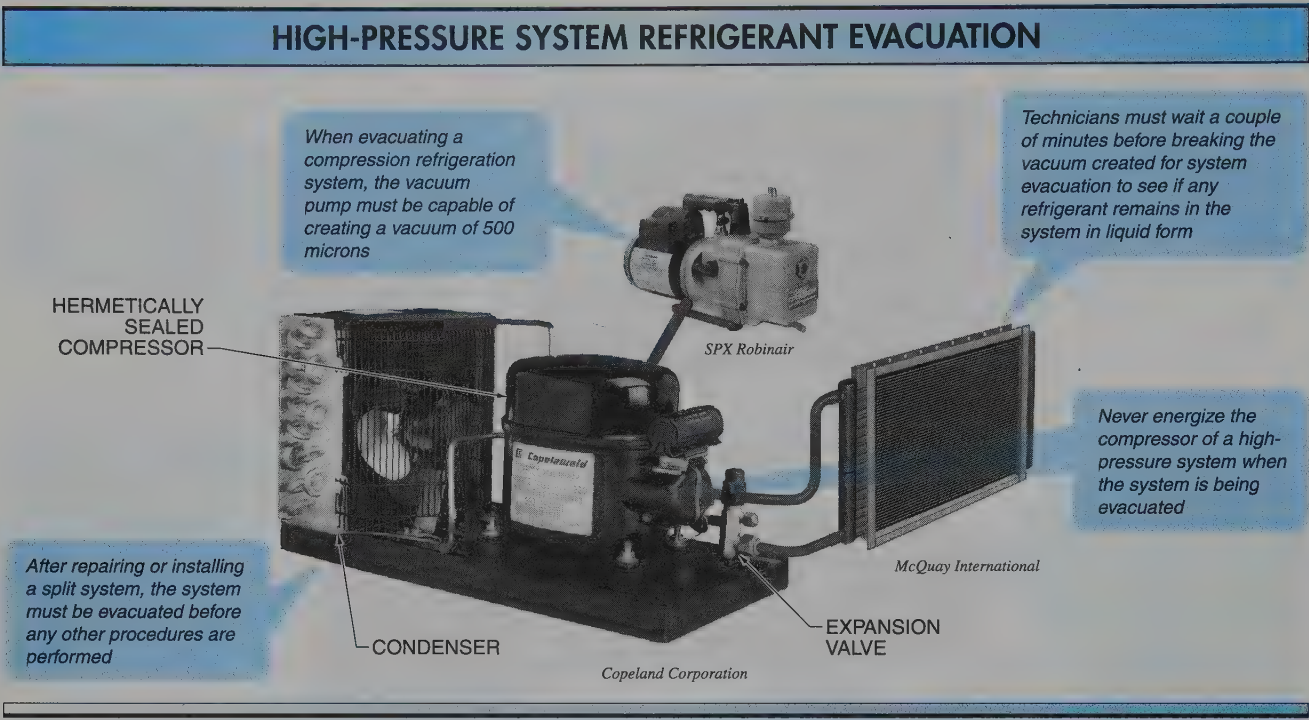


Figure 11-9. When a high-pressure system is installed or repaired, the technician must first evacuate the system before proceeding with any other system procedures.

> Deep vacuum is typically measured in microns.
>
> Technical Fact

- When a deep vacuum in a high-pressure system with a hermetically sealed compressor has been created because of system evacuation, the compressor motor windings can be damaged if the compressor motor is energized.
- After achieving the required evacuation vacuum on a high-pressure appliance, technicians must wait a few minutes to see if the system pressure rises. Rising system pressure indicates that there is still refrigerant in liquid form in the system or that refrigerant is in the compressor oil.

> A pressure regulator and relief valve must always be used when pressurizing a system with dry nitrogen.
>
> Technical Fact

High-Pressure System Dehydration

Dehydration is the removal of moisture from a high-pressure appliance.

- Dehydration of a high-pressure system is achieved by using a filter/dryer on an operating system, or using a vacuum pump to remove the moisture when not operating.
- Dry nitrogen is used to break the first vacuum after dehydrating a system by using the double evacuation method.

Using Nitrogen in High-Pressure Systems

When a new high-pressure system is assembled (installed) and is ready for leak testing, the first procedure is to pressurize the system with nitrogen and leak check the system. During evacuation of a high-pressure system with large amounts of moisture, it may be necessary to increase pressure in the system with nitrogen to counteract any freezing.

Oil Foaming

Many semi-hermetic compressors are equipped with an oil sight glass, which enables technicians to watch for foaming oil. Oil foaming occurs in the crankcase of a compressor due to migration of refrigerant into the oil. Oil foaming can contribute to

compressor failure (burnout). When a compressor burns out, an oil sample must be taken for analysis.

High-Pressure System Refrigerant Charging

The vapor method of charging is used when charging a system with a small amount of refrigerant. If a high-pressure system is to be charged with a large amount of refrigerant, the refrigerant is charged as a liquid. Technicians must be aware of the possibility of air infiltrating the high-pressure system or charging machine system, and also be aware of the freezing of moisture that may be present in the system.

- Charging of a high-pressure system can be accomplished by the liquid or vapor refrigerant method. Always check system pressures with gauges to verify the correct amount of charge. **See Figure 11-10.**
- Charging liquid refrigerant into a high-pressure system must be performed through the high-pressure side of the system. For example, to charge a system that has a specified charge of 80 lb, a technician must charge liquid refrigerant through the liquid-line service valve (king valve).
- A high-pressure system has a risk of freezing when the system is under a vacuum when refrigerant charging begins. The charging of high-pressure liquid refrigerant should not begin until the refrigerant is above 32°F.

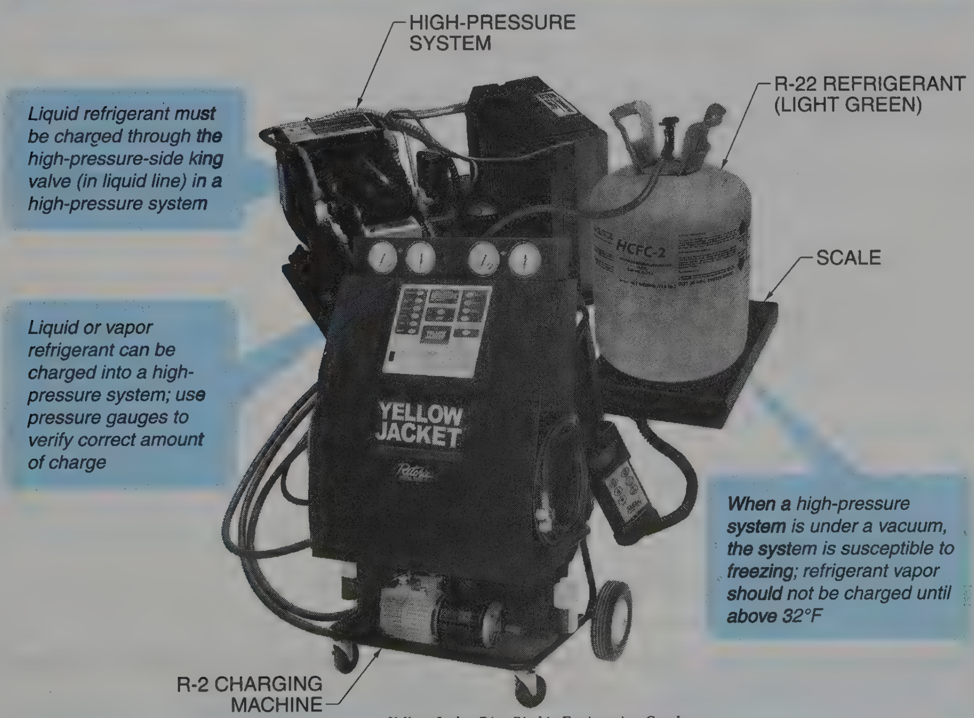
Noncondensables in a high-pressure system result in higher discharge pressures from the refrigerant charging machine.

▶ Technical Fact

Recovered refrigerant should be safe to charge back into a system if not contaminated. When refrigerant has been recovered from an air conditioning system and held in a reliable cylinder, refrigerant can probably be charged back into the system when the condenser coil is replaced.

▶ Technical Fact

HIGH-PRESSURE SYSTEM REFRIGERANT CHARGING



Yellow Jacket Div., Ritchie Engineering Co., Inc.

Figure 11-10. Technicians must be aware of whether the refrigerant being charged into a high-pressure system is a liquid or vapor, to properly charge the refrigerant into the correct section of the system.

High-Pressure System Service Tips

During service, the technician must understand the operation and function of all the valves on a high-pressure system. Three-way valves have three ports and two seats, as two-way valves have two ports and one seat. To *backseat a valve* is to turn the valve in the counterclockwise direction to bring the valve stem to the front position.

- A suction service valve in the backseated position will have the gauge port closed. The valve must be cracked off of the backseat (all ports open) to open the gauge port.
- During service, quick couplers, self-sealing hoses, low-loss fittings, and hand valves are used to minimize refrigerant releases when hoses are connected and disconnected from system and recovery/charging machines.
- When a high-pressure system is opened for servicing, the filter/dryer should be replaced.

Discussion Questions

1. How is the equipment classified as Type II (high-pressure equipment) defined?
2. Why is the nameplate on an air conditioning or refrigeration system useful?
3. How are the components of a high-pressure system different from the components found in small appliances?
4. How are the accessories found in a high-pressure system different from the accessories found in small appliances?
5. What special procedures are required to recover refrigerant from high-pressure systems with recovery machines that work with more than one refrigerant?
6. How do special precautions protect high-pressure systems and recovery equipment from damage when recovering refrigerant from high-pressure systems?
7. How are high-pressure systems leak tested?
8. What special equipment is needed when recovering R-134a refrigerant?
9. What procedures can decrease the time it takes to recover refrigerant from a high-pressure system and minimize the loss of compressor oil?
10. Why are refrigerants recovered from the lowest point in a high-pressure system?
11. What procedures are used to evacuate high-pressure systems?
12. How is a high-pressure system dehydrated?
13. Why must oil foaming be prevented?
14. How are high-pressure systems charged with refrigerant?
15. How is a service valve backseated?

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REVIEW QUESTIONS

Name ______________________________ Date ______________

_______________ **1.** Type II (high-pressure equipment) is categorized by ____.

A. being low volume
B. having open compressors
C. having defrost bypasses
D. containing over 5 lb of refrigerant

_______________ **2.** A technician who is servicing a residential split system providing comfort air conditioning would expect to find ____ refrigerant.

A. R-11
B. R-12
C. R-22
D. R-502

_______________ **3.** EPA regulations require that leaking commercial and industrial process refrigeration systems be repaired when the leak rate exceeds ___% of the charge per year.

A. 0
B. 15
C. 25
D. 35

_______________ **4.** Appliances containing CFC refrigerants need be evacuated only to atmospheric pressure when ____.

A. the repair is major
B. the repair is followed by an evacuation of the appliance to the environment
C. leaks in the appliance make evacuation to the prescribed level unattainable
D. the appliance is being disposed of

_______________ **5.** The component directly following the evaporator of a high-pressure refrigeration system is the ____.

A. receiver
B. metering device
C. accumulator
D. condenser

_______________ **6.** The primary water source for a water-cooled condensing coil of a recovery machine is ____.

A. the facility's sprinkler system water
B. the local municipal water supply
C. a cooling tower
D. an air-cooled chiller

_______________ **7.** Before recovering refrigerant from a system with R-22 refrigerant, technicians using recovery/recycling machines to recover R-502 refrigerant must ____.

A. do nothing, as long as the recovery machine is not full
B. replace the gauges and expansion valve on the recovery machine
C. change the filter and gauges on the recovery machine
D. recover as much of the R-502 from the recovery machine as possible, change the filter, and evacuate the machine

_____ 8. When under a deep vacuum, a hermetically sealed compressor of a high-pressure system can overheat because the ___.

A. refrigerant oil must be kept warm to avoid oil breakdown
B. motor windings rely on the flow of refrigerant through the compressor for cooling
C. rpm of the compressor is increased to compensate for the loss of refrigerant
D. refrigerant is superheated from the evaporator

_____ 9. Technicians servicing high-pressure systems must provide special hoses, gauges, vacuum pumps, recovery machines, and oil containers designed only for ___ refrigerants.

A. R-12
B. R-134a
C. R-502
D. HCFC-123

_____ 10. Refrigerant recovery time from a high-pressure system can be decreased by ___.

A. recovering the refrigerant into an empty recovery container
B. packing the recovery container in hot charcoals
C. placing the recovery machine higher than the recovery container
D. recovering liquid refrigerant then recovering refrigerant vapor

_____ 11. Refrigerant must be removed from the condenser outlet of a system when the ___.

A. recovery machine is above the compressor of the system
B. metering device is a thermostatic expansion valve
C. condenser is below the receiver of the system
D. system accumulator is inoperative

_____ 12. When a high-pressure system has an air-cooled condenser on the roof of the building and the evaporator is on the first floor, refrigerant recovery is from the ___.

A. liquid line leaving the condenser
B. liquid line entering the evaporator
C. suction line leaving the evaporator
D. suction line entering the compressor

_____ 13. During evacuation of a system with large amounts of moisture, it may be necessary to increase pressure in the system with ___ to counteract freezing.

A. a trace gas of R-22
B. nitrogen
C. a smaller vacuum pump
D. a brief energizing of the compressor

_____ 14. To charge 80 lb or more of refrigerant into the high-pressure side of a system, the refrigerant must be charged as a ___ through the ___ line service valve.

A. liquid; liquid
B. liquid; suction
C. vapor; liquid
D. vapor; suction

_____ 15. Backseating a suction service valve will close the ___ port(s).

A. compressor
B. suction line
C. gauge
D. Schrader valve

Twenty-five Type II (high-pressure equipment) questions are found on a typical Type II certification test. The information covered by the Type II questions includes refrigeration principles, safety, refrigerants, regulatory requirements, equipment disposal, and service practices.

12

Type II (High-Pressure Equipment) Certification Test Questions

Name ______________________________ Date ______________

_______________ **1.** A technician who is servicing a residential split system providing comfort air conditioning would expect to find ___ refrigerant.

A. R-502

B. R-22

C. R-11

D. R-12

_______________ **2.** When under a deep vacuum, a hermetically sealed refrigeration compressor's ___.

A. oil must be kept warm to avoid oil breakdown

B. motor insulation improves the dielectric strength of the motor

C. crankcase heater must be energized

D. motor windings could be damaged if energized

_______________ **3.** After installation of a field-piped split system, the unit should first be ___.

A. evacuated

B. pressurized with R-22 and leak checked

C. pressurized with R-12 and leak checked

D. pressurized with nitrogen and leak checked

_______________ **4.** EPA regulations require that all appliances containing more than 50 lb of refrigerant (except for commercial and industrial process refrigeration) be repaired when the leak rate exceeds ___% of the charge per year.

A. 0

B. 15

C. 25

D. 35

_______________ 5. EPA regulations require that leaking commercial and industrial process refrigeration systems be repaired when the leak rate exceeds ___% of the charge per year.

A. 0

B. 15

C. 25

D. 35

_______________ 6. Refrigerant should be removed from the condenser outlet when the ___.

A. condenser is below the receiver

B. condenser is on the roof

C. compressor is inoperative

D. liquid line is the lowest part

_______________ 7. System-dependent recovery equipment cannot be used when the ___.

A. compressor of the appliance is operational

B. ambient temperature is over 105°F

C. appliance contains over 15 lb of refrigerant

D. appliance is leaking

_______________ 8. It is not true of recycling and recovery equipment manufactured after November 15, 1993, that the equipment must ___.

A. be tested by an EPA-approved third party

B. meet vacuum standards more stringent than those met by equipment manufactured before November 15, 1993

C. be equipped with low-loss fittings

D. be able to handle more than one refrigerant

_______________ 9. Technicians providing service work for systems with R-12, R-502, and R-134a refrigerants must provide special hoses, gauges, vacuum pump, recovery machine, and oil containers to be used with ___ refrigerant(s).

A. R-134a

B. R-502

C. R-12 and R-134a

D. there is no need to take any special precautions since there is little difference between the refrigerants

_______________ 10. A technician using a recovery/recycling machine to recover R-502 refrigerant must ___ before recovering refrigerant from a system with R-22 refrigerant.

A. do nothing, as long as the recovery machine is not full

B. change the expansion valve on the recovery machine

C. change the filter and expansion valve on the recovery machine

D. recover as much of the R-502 from the recovery machine as possible, change the filter, and evacuate

_______________ 11. When a new system has been assembled (built up) and ready for leak testing, the first procedure to perform is to ___.

A. evacuate the system

B. pressurize the system with an inert gas and leak check it

C. pressurize the system with the refrigerant to be used

D. introduce an initial charge of refrigerant and start the compressor

_______________ **12.** As defined by ASHRAE Standard 15, a sensor and alarm are required for A1 refrigerants to sense ___.

A. ozone

B. CFC contamination

C. oxygen deprivation

D. HCFC leaks

_______________ **13.** When first inspecting a system with a hermetically sealed compressor when the system is known to be leaking, a technician should look for ___.

A. frost on the tubing

B. puddles of refrigerant

C. particles of filter/dryer core

D. traces of refrigerant oil

_______________ **14.** Recovering refrigerant from a system in a vapor state will minimize the loss of ___.

A. water

B. refrigerant oil

C. refrigerant

D. vacuum in the system

_______________ **15.** In general, the most common maintenance task that must be performed on most refrigerant recycling machines is to ___.

A. check the compressor seals

B. change the electrical fuses

C. change the oil and filter

D. replace the moisture sight glass

_______________ **16.** Every high-pressure refrigeration system shall be protected by a ___.

A. pressure relief device

B. properly located stop valve

C. low-pressure control

D. refrigerant receiver

_______________ **17.** Before using a recovery unit to remove a refrigerant charge from a system, the technician must ___.

A. ensure that the recovery container has a dip tube

B. add compressor oil to the system

C. ensure that the system is at atmospheric pressure

D. evacuate the system and recovery container

_______________ **18.** A technician sent out to service a 60-ton packaged rooftop unit can find which type of refrigerant is in the system by ___.

A. looking at the nameplate of the unit

B. using a service gauge set and a refrigerant card

C. asking the owner of the system

D. looking on top of the TXV

_______________ **19.** A system with a hermetically sealed compressor has the potential to overheat when recycling or recovery equipment is used to draw deep vacuums because ___.

A. it runs faster than other equipment

B. the motor relies on the flow of refrigerant through the compressor for cooling

C. it has a higher compression ratio limit than other equipment

D. the oils used in hermetic compressors burn at lower temperatures than the oils used in other equipment

______ **20.** Noncondensables in a refrigeration system result in ___ operating ___ pressures.

A. lower; suction
B. higher; suction
C. lower; discharge
D. higher; discharge

______ **21.** A reciprocating compressor must not be energized when ___.

A. the discharge service valve is closed
B. the suction service valve is open
C. the discharge service valve is open
D. there is a demand for cooling

______ **22.** The primary water source for a recovery machine with a water-cooled condensing coil is ___.

A. a cooling tower
B. a chiller
C. the local municipal water supply
D. de-ionized water

______ **23.** A moisture-indicating sight glass is useful for ___ of a high-pressure system.

A. identifying the type of refrigerant
B. checking the refrigerant temperature
C. providing subcooling
D. checking the refrigerant charge

______ **24.** When evacuating a mechanical compression system, the vacuum pump must be capable of pulling a vacuum of ___.

A. 1″ Hg
B. 2″ Hg
C. 500 microns
D. 1000 microns

______ **25.** Appliances containing CFC refrigerants need only be evacuated to atmospheric pressure when ___.

A. the repair is major
B. the repair is followed by an evacuation of the appliance to the environment
C. leaks in the appliance make evacuation to the prescribed level unattainable
D. the appliance is being disposed of

______ **26.** Replacement of a(n) ___ is a repair that would always be considered "major" under EPA regulations.

A. evaporator coil
B. filter/dryer
C. Schrader valve core
D. condenser fan motor

______ **27.** ___ is an indication of a leak in a high-pressure system.

A. High head pressure
B. Low water pressure
C. Excessive superheat
D. Frequent purging

_____ **28.** When using recovery and recycling equipment manufactured after November 15, 1993, technicians must evacuate an appliance component containing more than 200 lb of CFC-12 to ___ before making a major repair.

A. 0 psig
B. 4″ Hg vacuum
C. 10″ Hg vacuum
D. 15″ Hg vacuum

_____ **29.** When using recovery and recycling equipment manufactured before November 15, 1993, technicians must evacuate an appliance containing 10 lb of CFC-500 to ___ before disposing of the appliance.

A. 0 psig
B. 4″ Hg vacuum
C. 10″ Hg vacuum
D. 15″ Hg vacuum

_____ **30.** A technician is changing the compressor of a system containing 40 lb of R-502 refrigerant. The recycling equipment being used was manufactured after November 15, 1993. In addition to isolating the compressor as much as possible, the technician must ___.

A. simply remove the compressor
B. evacuate the isolated section of the system to atmospheric pressure, then remove the compressor
C. evacuate the isolated section of the system to 10″ Hg vacuum, hold the vacuum, and remove the compressor if system pressure does not rise
D. evacuate the isolated section of the system to 15″ Hg vacuum, hold the vacuum, and remove the compressor if system pressure does not rise

_____ **31.** During service, quick couplers, self-sealing hoses, and hand valves can be used to ___.

A. minimize the chance of explosion during the reclamation of mixed refrigerants
B. simplify evacuation during recycling
C. minimize refrigerant release when hoses are connected and disconnected
D. prevent vapor lock during liquid transfer

_____ **32.** The removal of refrigerant from a system can be conducted more quickly by ___.

A. using a smaller recovery vessel
B. packing the recovery vessel in ice
C. using a standard vacuum pump
D. heating the recovery vessel

_____ **33.** With an air-cooled condenser on the roof of a building and the evaporator on the first floor, refrigerant recovery must start from the _____.

A. vapor line entering the condenser
B. discharge line of the compressor
C. liquid line entering the evaporator
D. suction line before the compressor

_____ **34.** Undamaged refrigerant has been recovered from an air conditioning system and stored in a reusable cylinder in order to replace the condenser coil. The refrigerant ___.

A. can be charged back into the system
B. should be replaced with R-123
C. must be reclaimed
D. must be destroyed

______ 35. The component directly following the evaporator of a high-pressure refrigeration system is the ___.

A. receiver
B. feed device
C. accumulator
D. condenser

______ 36. The state of the refrigerant leaving the receiver of a high-pressure refrigerant system is a ___.

A. low-pressure liquid
B. low-pressure vapor
C. high-pressure liquid
D. high-pressure vapor

______ 37. According to ASHRAE Standard 15, R-12, R-134a, and R-11 refrigerants require an equipment room ______.

A. fire extinguisher (Halon)
B. electronic leak detector
C. recovery machine for each refrigerant
D. oxygen deprivation sensor

______ 38. The evaporation temperature of R-134a at 14.7 psia is ___°F.

A. –21
B. –15
C. –5
D. –1

______ 39. A deep vacuum is usually measured in ___.

A. psig
B. psia
C. inches of mercury absolute
D. microns

______ 40. The refrigerant pressure of a storage cylinder with R-12 refrigerant at room temperature (70°F) is approximately ___ psig.

A. 70
B. 85
C. 212
D. 300

______ 41. After liquid refrigerant has been recovered from an appliance, any remaining refrigerant vapor is ___.

A. purged to the atmosphere
B. isolated in the appliance
C. pumped into the receiver of the appliance
D. condensed by the recovery system for removal

______ 42. After achieving the required recovery vacuum on an appliance, technicians must ___.

A. immediately disconnect the recycling or recovery equipment and open the system for service
B. wait a few minutes to see if the system pressure rises, indicating that there is still refrigerant in a liquid state or in the oil
C. immediately break the vacuum with nitrogen and open the system for service
D. immediately pressurize the system with nitrogen and perform a leak test

_______________ **43.** The method used to charge a system that has a specified charge of 80 lb or more is to charge the refrigerant as a ___ through the ___ service valve.

A. vapor; suction
B. liquid; discharge
C. liquid; suction
D. liquid; liquid-line

_______________ **44.** If a system is opened for servicing, the ___ should be replaced.

A. filter/dryer
B. thermostat
C. metering device
D. crankcase heater

_______________ **45.** Oil foaming usually occurs in the ___ area of a high-pressure refrigeration system.

A. condenser
B. evaporator
C. compressor
D. expansion device

_______________ **46.** Pressure relief valves must not be installed ___.

A. in series
B. in parallel
C. vertically
D. horizontally

_______________ **47.** Some refrigeration systems use an open compressor. If a system with an open compressor is not used for several months, the part of the compressor that is most likely to leak is the ___.

A. suction service valve
B. compressor shaft seal
C. oil drain plug
D. discharge service valve

_______________ **48.** Testing with soap bubbles is used ___.

A. to pinpoint refrigerant leaks
B. only with CFCs
C. to detect compressor overheating
D. to verify airflow through heat exchangers

_______________ **49.** Technicians save time recovering refrigerant from a high-pressure system by removing as much of the refrigerant as possible in the ____ state.

A. final
B. initial
C. liquid
D. vapor

_______________ **50.** In a high-pressure refrigeration system utilizing a thermal expansion valve, the component directly following the condenser is the ___.

A. receiver
B. metering device
C. accumulator
D. evaporator

__________ **51.** Backseating a suction service valve will close the ___ port(s).

A. suction line and compressor

B. compressor and gauge

C. compressor

D. gauge

__________ **52.** To remove ice from sight glasses or viewing glasses, use ___.

A. R-11 refrigerant

B. an alcohol spray

C. water

D. a screwdriver or scraper

__________ **53.** When a refrigerant trace gas becomes absolutely necessary, ___ is the refrigerant that should be used to identify a leak.

A. CFC-11

B. CFC-114

C. HCFC-22

D. HCFC-123

__________ **54.** In a high-pressure system, to recover liquid refrigerant, a technician must connect one recovery machine hose to the ___.

A. suction line of the compressor

B. discharge line of the compressor

C. liquid line

D. top of the condenser

__________ **55.** When an operating high-pressure system has a receiver (storage tank) that requires service, ___.

A. the compressor should be isolated

B. liquid refrigerant should be recovered last

C. refrigerant should be recovered in the receiver

D. a gauge pressure must be achieved by venting

__________ **56.** Systems that use R-134a must be leak checked with ___.

A. trace CFC refrigerants

B. trace HCFC refrigerants

C. pressurized nitrogen

D. compressed air

__________ **57.** Acids, moisture, and oils are found in _____ refrigerants.

A. new

B. recycled

C. reclaimed

D. recovered

__________ **58.** An oil sample should be taken when ___.

A. a new filter has been installed

B. a system has had a compressor burnout

C. the system is not cooling properly

D. recycled refrigerant has been added to the system

_______________ **59.** The ___ is not part of the low-pressure side of a high-pressure system.

A. evaporator
B. receiver
C. suction line
D. accumulator

_______________ **60.** When evacuating a system with large amounts of moisture, it may be necessary to increase pressure with a gas such as ___ to counteract freezing.

A. R-12
B. R-22
C. air
D. nitrogen

_______________ **61.** Before transferring refrigerant to an empty storage cylinder, the ___.

A. refrigerant should be chilled
B. refrigerant should be mixed
C. cylinder must be heated
D. cylinder must be evacuated

_______________ **62.** Dry nitrogen must be used to break the first vacuum when dehydrating a system by the double evacuation method. However, dry nitrogen ___.

A. often contains contaminants
B. is expensive
C. is toxic under pressure
D. can be dangerous if not used with a pressure regulator

_______________ **63.** When R-22 refrigerant is charged into a refrigeration system as a liquid, any moisture in the system may freeze if charging is begun from a vacuum level with refrigerant temperature below ___ °F.

A. 32
B. 72
C. 87
D. 120

_______________ **64.** Moisture is removed from the refrigerant of an operating system by ___.

A. purging the condenser
B. draining the oil separator
C. reducing water flow to the condenser
D. using a filter/dryer

_______________ **65.** ___ a high-pressure system must be performed prior to charging any refrigerant into the system.

A. Leak testing
B. Dehydrating
C. Starting the compressor for
D. Energizing valve actuators for

13 Type III (Low-Pressure Equipment)

Low-pressure equipment typically uses refrigerants such as CFC-11 and HCFC-123 that boil at a relatively high temperature. Leaks on the low-pressure side of the system are inward (atmosphere enters system). Leaks on the high-pressure side of the system are outward (refrigerant escapes system) and can pose serious health hazards.

LOW-PRESSURE EQUIPMENT

The largest systems in the air conditioning and refrigeration industry are made up of low-pressure equipment. The EPA also refers to low-pressure equipment as low-pressure appliances. The size of the equipment and amount of refrigerant, as well as the potential danger to equipment, people, and the environment, are of particular concern to the EPA. Low-pressure equipment typically operates below atmospheric pressure (in a vacuum).

ASHRAE Guideline 3-1996 states that when pressure in a system rises from 1 mm Hg to a level above 2.5 mm Hg during vacuum testing, the system must be checked for leaks.

LOW-PRESSURE REFRIGERANTS

The two most common refrigerants used in low-pressure equipment are R-11 and R-123. R-11 is a CFC refrigerant that has been in use for many years and is being replaced by HCFC-123 refrigerant. At the present time, HCFC-123 is the only suitable replacement for CFC-11 refrigerant. Both refrigerants have similar boiling points and operating pressures. CFC-11 boils at 74.9°F at 0 psi (14.696 psia). HCFC-123 boils at 81.7°F at 0 psi (14.696 psia). R-11 and R-123 refrigerants have relatively high boiling points compared to most refrigerants, which results in low system operating pressures. **See Figure 13-1.** Chillers using CFC-11 and HCFC-123 refrigerants require purge units because the systems operate in a vacuum.

Because low-pressure equipment is very large (with large amounts of water), precautions must be taken to prevent any type of freeze-up in the system. When CFC-11 refrigerant is at a pressure of 18.1″ Hg vacuum, the saturation temperature will be about 32°F and the water in the heat exchanger would begin to freeze.

The pressure corresponding to 32°F for HCFC-123 is about 20″ Hg vacuum. Technicians must be cautious not to allow chillers with R-11 and R-123 refrigerants to reach vacuum levels that would cause water to begin freezing.

Even though CFC-11 refrigerant and HCFC-123 refrigerant are quite similar in properties and use, the ozone depletion potential (1 and 0.02 respectively) and global warming potential (4 and 0.09 respectively) of the two refrigerants are very different.

LOW-PRESSURE REFRIGERANT OPERATING PRESSURES

Refrigerant Type	Evaporator Pressure at 40°F*	Condenser Pressure at 105°F†
CFC-11	15.6	10.9
HCFC-123	18.1	8.1

* in in. Hg vacuum
† in psi

Figure 13-1. R-11 and R-123 refrigerants have relatively high boiling points compared to most refrigerants, which results in low system operating pressures.

REGULATORY REQUIREMENTS

EPA regulations require that all appliances containing more than 50 lb of refrigerant (except for commercial and industrial process refrigeration) be repaired when the leak rate exceeds 15% of the charge per year. EPA regulations require that leaking commercial and industrial process refrigeration systems be repaired when the leak rate exceeds 35% of the charge per year. All equipment in the low-pressure (Type III) category typically contains over 50 lb of refrigerant, requiring that all low-pressure equipment leaks be repaired.

Replacement of any major component of a low-pressure appliance such as an evaporator coil is considered to be a "major" repair under EPA regulations. **See Figure 13-2.** Prescribed evacuation levels must be met when major repairs are performed on low-pressure appliances. Low-pressure appliances need not be evacuated all the way to prescribed levels when the repair is "minor" or when leaks in the appliance make evacuation to the prescribed level unattainable. Under EPA regulations, controlled hot water can be used to pressurize a low-pressure system for nonmajor repairs.

LOW-PRESSURE SYSTEM MAJOR AND MINOR REPAIRS

Major Repair	Minor Repair
Replace condenser	Replace temperature sensor
Replace compressor	Replace filter/dryer
Replace metering valve	Replace purge unit
Replace evaporator	Replace oil heater

Figure 13-2. Replacement of any major component of a low-pressure appliance such as an evaporator coil is considered to be a "major" repair, and replacement of a component such as a temperature sensor is considered to be a "minor" repair, under EPA regulations.

LOW-PRESSURE SYSTEM COMPONENTS

All mechanical refrigeration systems have four basic components (compressor, condenser, metering device, and evaporator), from the smallest unit to the largest system. Large low-pressure systems use orifice plates or float-type metering devices. The evaporators used in low-pressure systems are flooded-type tube-and-shell heat exchangers. The condensers are water-cooled

tube-in-shell heat exchangers. Centrifugal-type compressors are typically used on low-pressure systems.

Purge Units

A *purge unit* is a device that removes noncondensables (air and moisture) from the centrifugal system during normal operation and returns the recycled refrigerant to the system. The primary purpose of the purge unit on a low-pressure chiller with CFC-11 or HCFC-123 refrigerant is to remove all noncondensables from the system. CFC-11 and HCFC-123 refrigerants operate in a vacuum (below atmospheric pressure).

All low-pressure systems require a purge unit because they operate in a vacuum (below atmospheric pressure). Air and moisture can enter the system because part of the system operates in a vacuum. Low-pressure chillers typically have moisture entering the system by air leaks that bring air and moisture through gasketed areas or fittings. Low-pressure systems with open drive compressors are susceptible to leaks through the compressor shaft seal.

Excessive running of a purge system on a low-pressure chiller typically indicates a leaking chiller system. The continuous collection of moisture in the purge unit of a low-pressure refrigeration system indicates that the condenser or chiller barrel tubes are leaking. High head pressure is an indication of air in a low-pressure system.

The suction line of a purge unit is from the top of the condenser (noncondensables accumulate in the condenser), and the discharge of the purge unit returns all condensables (refrigerants) to the system at the evaporator. **See Figure 13-3.** Inefficient purge units cause refrigerant loss to the atmosphere when venting. High-efficiency purge units are units that discharge a low percentage of refrigerant with the air when venting. Technicians must leak test and repair leaks to chillers with CFC-11 or HCFC-123 refrigerants to reduce refrigerant loss through low-pressure chiller purge units.

Rupture Discs

In the event of excessive pressure, pressure is released from a centrifugal chiller safely with a rupture disc. A rupture disc is a one time use pressure safety device. Low-pressure chillers typically use a rupture disc mounted on the evaporator housing to protect the system from overpressurization. A typical low-pressure chiller rupture disc relieves pressure at 15 psi. The discharge from a rupture disc must be piped outdoors for venting refrigerant.

LOW-PRESSURE REFRIGERANT RECOVERY AND RECYCLING

Low-pressure refrigerant recycling and recovery equipment manufactured after November 15, 1993, must be tested by an EPA-approved third party; must meet vacuum standards more stringent than those met by equipment manufactured before November 15, 1993; and must be equipped with low-loss fittings. With a low-pressure chiller, technicians must recover the liquid refrigerant first, and then recover the refrigerant vapor. During refrigerant vapor removal from the low-pressure system, the system water pumps, recovery compressor, and recovery condenser water supply must all be ON. If a technician is recovering refrigerant from a chiller suspected of having leaking tubes, the technician must drain the water from the evaporator and condenser as a precaution.

Low head pressure is an indication of refrigerant undercharge in a low-pressure system.

Technical Fact

Leak testing a low-pressure refrigeration system with nitrogen in excess of 10 psi could cause a rupture disk to fail.

Technical Fact

PURGE UNIT CONNECTIONS

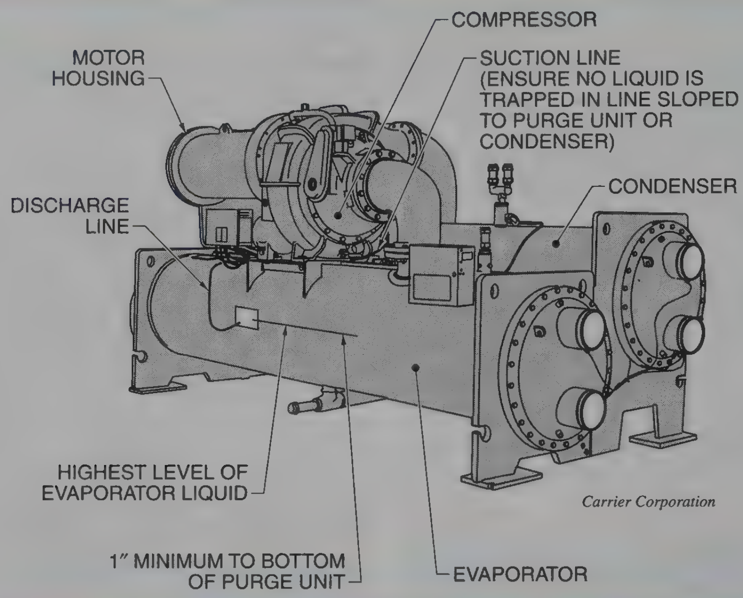

Figure 13-3. The suction line of a purge unit is located at the top of the condenser (noncondensables accumulate in the condenser), and the discharge of the unit returns all condensables (refrigerants) back into the system at the evaporator.

LOW-PRESSURE REFRIGERANT RECOVERY AND CHARGING PROCEDURES

Technicians using low-pressure refrigerant recovery machines must follow standard procedures:

- A rupture disc on the evaporator of a low-pressure chiller relieves at 15 psi. **See Figure 13-4.**
- The typical setting for the high-pressure cutout control on a recovery unit used for evacuating the refrigerant from a low-pressure chiller is 10 psi.
- The local municipal water supply is the primary water source for a water-cooled recovery unit condensing coil.
- A typical 350 ton chiller (an average-size low-pressure system) with CFC-11 refrigerant at 0 psi can have 100 lb of refrigerant vapor left in the system once all the liquid CFC-11 refrigerant has been removed.
- CFC-11 or HCFC-123 system refrigerant recovery starts with liquid refrigerant removal.
- After reaching the required recovery vacuum on a low-pressure appliance, a technician must wait a few minutes to see if the system pressure rises, indicating that there is still refrigerant in liquid form or refrigerant still in the oil.
- A heater used on a refrigerant container aids in the faster transfer of refrigerant vapor to a chiller.

A vacuum of 29″ Hg is equal to 25 mm Hg abs, 23,368 microns, and 0.452 psia.

Technical Fact

LOW-PRESSURE REFRIGERANT RECOVERY AND CHARGING

Figure 13-4. Technicians using low-pressure refrigerant recovery machines must take special precautions when recovering or charging low-pressure refrigerants.

SERVICE PRACTICES

Leak testing a low-pressure chiller can be accomplished with a charged (pressurized) system or empty system. With the system charged or empty, the pressure on the low-pressure side has to be increased. To evacuate large-volume systems requires more time than to evacuate small-volume systems. Refrigerant charged into a low-pressure system must always be charged as refrigerant vapor first to avoid freeze-ups, then as liquid refrigerant to speed up the process.

ASHRAE Standard 15

ASHRAE Standard 15 requires the use of room sensors and alarms to detect refrigerant leaks. Under ASHRAE Standard 15, a room oxygen deprivation sensor and alarm is required. Monitors can be used for sensing oxygen deprivation or refrigerant. The standard also requires that each machinery room shall activate an alarm and mechanical ventilation before refrigerant concentrations exceed the threshold limit value (TLV) and the time weighted average (TWA). ASHRAE Standard 15 applies to all refrigerant safety groups.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers

Removing Oil

When removing oil from a low-pressure system, the compressor oil should be heated to 130°F, because less refrigerant is contained in the oil at the higher temperature. An oil sample should be taken if recycled refrigerant has been added to a low-pressure system.

Refrigerant Flammability

The flammability of a refrigerant depends on the flammability limits and heat of combustion measurements. The flammability limits are lower flammability limit and upper flammability limit. The lower flammability limit (LFL) is the lowest concentration of the refrigerant that will burn in air at given conditions of temperature and pressure. The upper flammability limit (UFL) is the highest concentration of the refrigerant that will burn in air at a given temperature and pressure.

Heat of combustion is the energy released when a refrigerant is burning.

	R-11	R-123	R-12	R-143a	R-122	R-717
	Low Pressure		High Pressure			
LFL-UFL (% volume in air)	none	none	none	none	none	15–25
Heat of combustion (MJ/kg)	0.9	2.1	−0.8	4.2	2.2	22.5
Safety classification	A1	B1	A1	A1	A1	B2

Environmental Protection Agency

Low-Pressure Refrigerant Charging

When charging a low-pressure chiller, freeze-up must be avoided. Refrigerant is typically added to a centrifugal chiller (machine) through the evaporator charging valve. When charging refrigerant, a technician must charge refrigerant vapor first to avoid any freeze-up, because liquid refrigerant charged into a low-pressure system under a deep vacuum will boil and lower temperatures enough to freeze water in the evaporator tubes. **See Figure 13-5.** Technicians know when enough refrigerant vapor has been charged into a low-pressure refrigeration system by the refrigerant saturation temperature increasing to 36°F. Once refrigerant vapor is charged, liquid refrigerant can then be charged into a low-pressure system. When recharging a low-pressure refrigeration system with CFC-11 refrigerant, 16.9″ Hg vacuum or less is required in the condenser and evaporator shells before charging the chiller with liquid refrigerant. Charging liquid refrigerant into a low-pressure refrigeration system that has a 29″ Hg vacuum will cause the system water to begin to freeze.

A1 refrigerants are considered safe in terms of toxicity and flammability but they require oxygen deprivation sensors.

Technical Fact

Refrigerant oil samples must be taken when recycled refrigerant has been added to a system.

Technical Fact

Low-Pressure System Leak Testing

A *hydrostatic tube test kit* is a set of tools used to determine if tubes are leaking in the condenser of a chiller. Another method to check for refrigerant leaks is to place a leak detector probe into the water box (with water removed) through an open drain valve. To determine if a low-pressure system is leaking, a standing pressure or standing vacuum test can be performed. According to ASHRAE Guideline 3-1990, if the pressure in a system rises 2.5″ Hg to a level above 1″ Hg during a standing vacuum test, the low-pressure system must be checked for leaks. An idle low-pressure refrigeration system pressure should be maintained slightly above atmospheric pressure to prevent air from entering the system. Low-pressure refrigeration systems that are charged can be efficiently leak checked by raising system pressure with heat using controlled hot water or heating blankets. When leak testing empty systems, nitrogen is used; typically,

10 psi is the maximum nitrogen test pressure allowed during leak testing.

Low-Pressure System Evacuation

Water must be circulated through a low-pressure chiller during a planned system evacuation in order to prevent the freezing of water. Technicians must be aware that when evacuating a system to prescribed levels, the use of a large vacuum pump could cause trapped water to freeze. **See Figure 13-6.** During a planned evacuation of a low-pressure system with large amounts of moisture, the system may require that pressure be increased with a gas, such as nitrogen, to counteract any freezing.

Twenty-nine inches of mercury vacuum (29″ Hg) is equivalent to 25 millimeters of mercury absolute (25mm Hg abs).

▶ Technical Fact

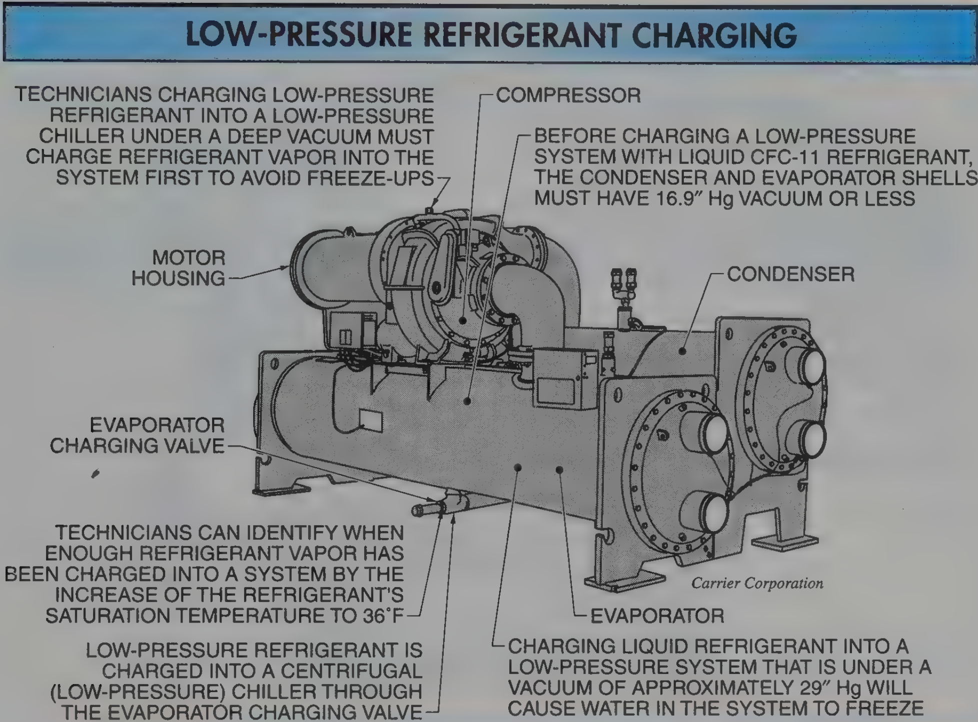

Figure 13-5. Technicians must charge refrigerant vapor into a low-pressure system first, before charging any liquid refrigerant, to avoid any system freeze-ups.

ARI-740 – PLANNED LOW-PRESSURE EQUIPMENT EVACUATIONS

Equipment Manufactured before November 15, 1993	Equipment Manufactured on or after November 15, 1993
25″ Hg	29 mm Hg or 29″ Hg

Figure 13-6. Technicians must be aware that when evacuating a low-pressure system to prescribed levels, the use of a large vacuum pump can cause trapped water to freeze.

Rupture Discs. A *rupture disc* is a nonmechanical pressure-relieving device that bursts open to relieve an overpressure condition at a predetermined pressure differential and specific temperature. Rupture discs consist of a rupture disc and holder assembly. Chiller evaporators use rupture discs to protect against excessive refrigerant pressures. **See Figure 13-7.** Rupture discs are typically used on chillers as emergency relief devices or secondary pressure relief devices to pressure relief valves for relieving pressure to a predetermined safe location (recovery container).

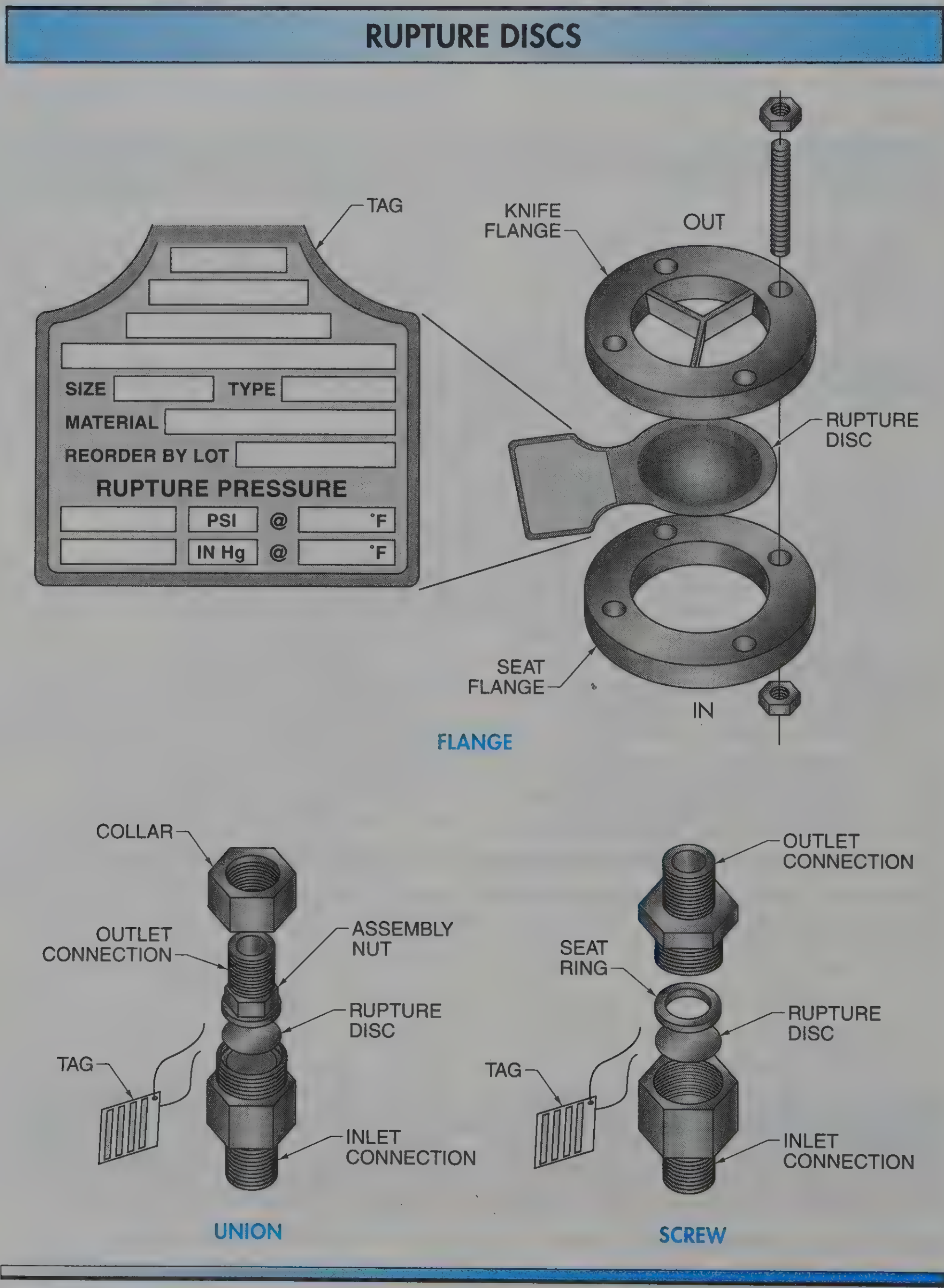

Figure 13-7. Rupture discs are found on chiller evaporators to protect against excessive refrigerant pressures.

Purge Units. When low-pressure chillers are running, the evaporator is in a vacuum. A leak in the refrigerant system allows air to enter the system. Air can cause several problems in a refrigeration system. Air contains oxygen and moisture that mix with the refrigerant, creating a mildly acidic condition. The acid can break down motor windings over time and cause the windings to short out. The air can also collect in the condenser and cause an increase in condenser pressure. If enough air is present in the condenser, the increased pressure will shut down the chiller because of high head pressure. Air can be removed from the system and problems can be avoided by using a purge unit to collect the air from the top of the condenser. **See Figure 13-8.**

A purge unit is a device used to maintain a chiller system free of air and moisture. A purge unit is a small condensing unit that takes a sample of the gases from the top of the condenser, compresses the sample using a compressor, and sends the sample into the condenser (purge drum) of the purge unit. If the sample condenses, it is a refrigerant gas and is returned to the evaporator. If the sample does not condense, the sample is "noncondensable" (air) and is released to the atmosphere.

PURGE UNITS

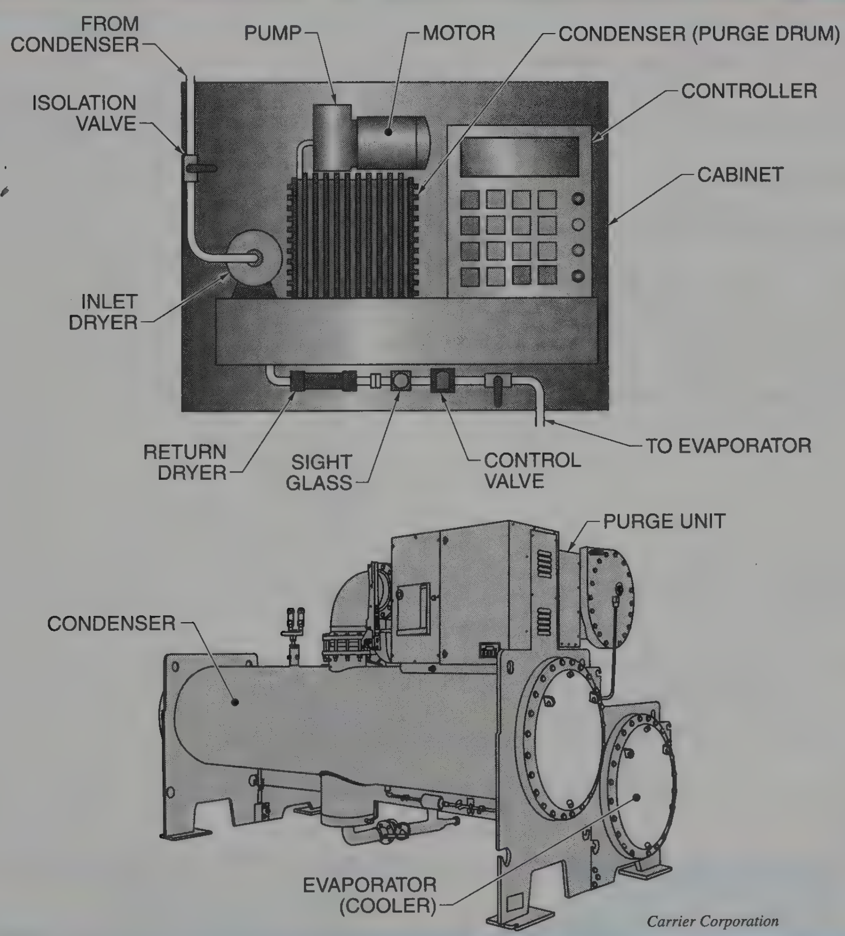

Figure 13-8. Purge units are devices used to maintain a chiller system free of air and moisture.

Discussion Questions

1. How are Type III appliances different from Type I and Type II appliances?

2. Why is it important that refrigerants such as R-11 and R-123 have high boiling points?

3. Why are freeze-ups possible when servicing low-pressure equipment?

4. Why does the EPA classify certain servicing procedures as "major" and "minor"?

5. Why are purge units required on all low-pressure equipment?

6. How are purge units connected to a low-pressure system?

7. What is the function of rupture discs used on low-pressure systems?

8. What procedures are required to recover refrigerant vapor from a low-pressure system?

9. Why must a technician wait a few minutes after evacuating a low-pressure system before performing any other service to the system?

10. How are service procedures different for low-pressure systems compared to other types of refrigeration systems?

11. How is refrigerant oil removed from a low-pressure system?

12. How is the refrigerant charged into a low-pressure system?

13. Why must technicians pay special attention to the pressures in a low-pressure system when charging refrigerant?

14. How are low-pressure systems leak tested?

15. How are low-pressure systems evacuated?

16. Why can a rupture disc be used as a relief valve?

17. How does a chiller purge unit function?

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Access Code: 827160

REVIEW QUESTIONS

Name ______________________________ Date ______________

______________ **1.** Low-pressure equipment typically operates ___.

A. at pressures of 60 psi or lower
B. at below freezing temperatures
C. in a vacuum
D. with less than 5 lb of refrigerant

______________ **2.** Refrigerant R-11 at 14.7 psia will boil at approximately ___°F.

A. 31
B. 60.3
C. 74.9
D. 92

______________ **3.** Under EPA regulations, ___ can be used to pressurize a low-pressure system for nonmajor repairs.

A. controlled hot water
B. oxygen
C. compressed air
D. nitrogen

______________ **4.** A purge unit removes ___ from the refrigerant in a low-pressure chiller.

A. the freeze point
B. compressor oil
C. solids
D. water (moisture)

______________ **5.** High-efficiency purge units are purge units that ___.

A. discharge a low percentage of refrigerant with the removed air
B. draw very little electrical power
C. discharge much less air than other units
D. are manufactured for a specific chiller

______________ **6.** A typical low-pressure chiller rupture disc relieves pressure at ___ psi.

A. 10
B. 15
C. 30
D. 60

______________ **7.** When recovering refrigerant vapor from a low-pressure system, the ___.

A. chiller water pump must be OFF
B. purge unit suction line must be from the bottom of the condenser
C. low-pressure system's rupture disk be replaced
D. recovery machine condenser water supply must be ON

______________ **8.** A ___ used with a refrigerant container aids in the transfer of refrigerant vapor to a chiller.

A. high-pressure charging machine
B. large vacuum pump
C. heater
D. bucket of ice

_______ 9. In an average 350 ton low-pressure chiller with CFC-11 refrigerant at 0 psi pressure, ___ lb of refrigerant vapor may be left once all the CFC-11 liquid refrigerant has been recovered.

A. 15
B. 60
C. 100
D. 500

_______ 10. To charge refrigerant into a low-pressure system, always charge ___ first, then charge ___ to avoid freeze-ups.

A. refrigerant vapor; liquid refrigerant
B. liquid refrigerant; refrigerant vapor
C. nitrogen; trace gas
D. trace gas; nitrogen

_______ 11. Excessive running of a purge system on a low-pressure chiller typically indicates ___.

A. blocked condenser tubes
B. condensables in the system
C. an undercharge of refrigerant
D. a leaking chiller system

_______ 12. To remove refrigerant oil from a low-pressure system, the compressor oil should be heated to ___°F, because less refrigerant contaminates the oil at the higher temperature.

A. 85
B. 130
C. 180
D. 212

_______ 13. When charging a low-pressure refrigeration system with CFC-11 refrigerant, ___ is required in the condenser and evaporator shells before charging the chiller with liquid refrigerant.

A. 14.7 psia
B. 0 psi
C. 16.9″ Hg vacuum or less
D. 29.0″ Hg vacuum or more

_______ 14. An idle low-pressure refrigeration system pressure should be maintained ___ to prevent air from entering the system.

A. below 16.9″ Hg
B. slightly below 29.1″ Hg
C. slightly above 0 psi
D. above 30 psi

_______ 15. During evacuation of a low-pressure system with a large amount of moisture, the system may require that pressure be ___ with ___ to counteract any freezing.

A. increased; nitrogen
B. increased; refrigerant
C. decreased; a vacuum pump
D. decreased; a recovery machine

14

Type III (Low-Pressure Equipment) Certification Test Questions

Twenty-five Type III (low-pressure equipment) questions are found on a typical Type III certification test. The information covered by the Type III questions includes refrigeration principles, safety, refrigerants, regulatory requirements, equipment disposal, and service practices.

Name ______________________________ Date ______________

______ **1.** A rupture disc mounted on a low-pressure refrigerant recovery container relieves at ___ psi.

A. 0
B. 5
C. 15
D. 20

______ **2.** A rupture disc mounted on a centrifugal chiller is connected to the ___ of the chiller.

A. condenser
B. evaporator
C. liquid line
D. economizer

______ **3.** ___ is a safety precaution that must be adhered to for low-pressure systems.

A. Charging refrigerant as a liquid first into a low-pressure system to avoid freeze-ups
B. Placing a refrigerant container in ice before charging
C. Leak testing chillers with nitrogen at 15 psi or greater
D. Preventing liquid refrigerant from contacting the skin

______ **4.** EPA regulations require that all low-pressure appliances containing more than 50 lb of refrigerant (except for commercial and industrial process refrigeration) be repaired when the leak rate exceeds ___% of the charge per year.

A. 0
B. 15
C. 25
D. 35

_____ 5. A heater used on a refrigerant container speeds up the transfer of ___ to the chiller.

A. liquid refrigerant
B. refrigerant vapor
C. lubricating oil
D. oil/liquid mixtures

_____ 6. Water must be circulated through a chiller during system evacuation in order to ___.

A. speed up the recovery process
B. prevent the loss of refrigerant to the atmosphere
C. prevent the freezing of water
D. maintain a constant refrigerant pressure

_____ 7. After recovering the liquid refrigerant from a low-pressure chiller, a technician must ___.

A. recover the refrigerant vapor
B. pressurize the system with nitrogen
C. remove the oil from the system
D. solvent-flush the entire system

_____ 8. On a centrifugal chiller, the purge unit suction line comes from the ___.

A. top of the condenser
B. compressor oil sump
C. top of the evaporator
D. suction line of the compressor

_____ 9. To reduce refrigerant loss from a purge unit on a CFC-11 chiller, technicians must ___.

A. seal the purge-unit discharge
B. leak test and repair leaks on the chiller
C. pipe the purge unit back into the low-pressure side
D. pipe the purge unit into the recovery container

_____ 10. ASHRAE Standard 15 requires that each machinery room ___ before refrigerant concentrations exceed the threshold limit value (TLV) and the weighted average (TWA).

A. have redundant oxygen deprivation sensors that activate
B. have emergency lighting that energizes
C. activate self-locking doors that lock
D. activate an alarm and mechanical ventilation

_____ 11. On low-pressure chillers, moisture most frequently enters the refrigeration system through ___.

A. air leaks in the rupture disc assembly
B. tube leaks
C. air leaks from gasketed areas or fittings
D. air leaks from the charging valve

_____ 12. When leak testing a low-pressure centrifugal chiller with nitrogen, the maximum test pressure is ___ psi.

A. 0
B. 10
C. 25
D. 50

_____ 13. Refrigerant R-11 at a pressure of 18.1″ Hg vacuum has a saturation temperature of about ___°F.

A. 28
B. 32
C. 36
D. 40

_______________ **14.** It is not true of low-pressure recycling and recovery equipment manufactured after November 15, 1993, that the equipment must ___.

A. be tested by an EPA-approved third party

B. meet vacuum standards more stringent than those met by equipment manufactured before November 15, 1993

C. be equipped with low-loss fittings

D. be able to handle more than one refrigerant

_______________ **15.** Low-pressure appliances can be pressurized to atmospheric pressure when ___.

A. the repair is major

B. the repair is followed by an evacuation of the appliance to the environment

C. leaks in the appliance make evacuation to the prescribed level unattainable

D. the appliance is being disposed of

_______________ **16.** After reaching the required recovery vacuum on a low-pressure appliance, technicians must ___.

A. immediately disconnect the recycling or recovery equipment and open the system for service

B. wait a few minutes to see if system pressure rises, indicating that there is still refrigerant in liquid form or in the oil

C. immediately break the vacuum with nitrogen and open the system for service

D. immediately pressurize the system with nitrogen and perform a leak check

_______________ **17.** A hydrostatic tube test kit can be used to ___.

A. determine if a tube leaks

B. blow all water out of condenser tubes

C. remove water from a low-pressure chiller

D. vent refrigerant to the atmosphere

_______________ **18.** Replacement of a(n) ___ would always be considered a "major" repair under EPA regulations.

A. metering device

B. filter/dryer

C. limit switch

D. evaporator fan motor

_______________ **19.** When recharging a refrigeration system with R-11, a vapor pressure of ___" Hg vacuum or less is necessary in the shells before charging with liquid refrigerant.

A. 8.1

B. 16.9

C. 19.7

D. 21.1

_______________ **20.** R-11 or R-123 system refrigerant recovery starts with ___.

A. refrigerant vapor removal

B. liquid refrigerant removal

C. liquid refrigerant and refrigerant vapor removal

D. oil separation

_______________ **21.** Charging refrigerant liquid into a refrigeration system that has a 29" Hg vacuum can cause the ___.

A. refrigerant to absorb excess moisture

B. purge unit to operate

C. system water to freeze

D. lubricating oil to freeze

_______________ 22. A technician knows when to stop charging refrigerant vapor into a system and start charging liquid into a system by a(n) ____.

A. increase in the refrigerant saturation temperature to 36°F

B. drop in the recovery unit liquid level

C. charge of refrigerant vapor for 15 min

D. drop in recovery machine pressure

_______________ 23. Under EPA regulations, ____ can be used to pressurize a system for a nonmajor repair.

A. nitrogen

B. controlled hot water

C. compressed air

D. carbon dioxide

_______________ 24. Refrigerant R-11 at 14.7 psia will boil at approximately ____°F.

A. 60.3

B. 74.9

C. 80.2

D. 100

_______________ 25. The primary purpose of a purge unit on a CFC-11 chiller is to ____.

A. remove CFCs from the system

B. keep lubricating oil flowing through the chiller

C. condense water out of the system

D. remove noncondensables from the system

_______________ 26. When using recovery or recycling equipment manufactured before November 15, 1993, technicians must evacuate low-pressure appliances to a level of ____ before making a major repair.

A. 0 psi

B. 15″ Hg vacuum

C. 25″ Hg vacuum

D. 29″ Hg vacuum

_______________ 27. The purge unit of a centrifugal chiller ____.

A. maintains chiller pressure above 15 psi

B. works best to remove compressor oil when the oil's temperature is below 130°F

C. returns refrigerant to the suction line of the compressor

D. has its suction line coming from the top of the chiller condenser

_______________ 28. A leak detector probe used to check for refrigerant leaks in the water box should be placed ____ once the water is removed.

A. at the rupture disc

B. through the vent valve

C. through the test plug opening

D. through an open drain valve

_______________ 29. According to ASHRAE guideline 3-1990, if the pressure in a system rises from 1 mm Hg to a level above ____ mm Hg during a standing vacuum test, the system should be checked for leaks.

A. 1.5

B. 2.0

C. 2.5

D. 3.0

_______ **30.** During refrigerant vapor removal from a low-pressure refrigeration system, the system water pumps ___.

A. must be on and the recovery machine compressor must be off

B. must be on, the recovery machine compressor must be on, and the recovery condenser water must be off

C. must be on, the recovery machine compressor must be on, and the recovery condenser water supply must be on

D. must be off and the recovery compressor must be on

_______ **31.** Low-pressure equipment typically operates ___.

A. at pressures of 60 psi or lower

B. at below freezing temperatures

C. in a vacuum

D. without any water being needed

_______ **32.** As defined by ASHRAE Standard 15, a sensor and alarm are required for A1 refrigerants to sense ___.

A. ozone

B. CFC contamination

C. oxygen deprivation

D. HCFC leaks

_______ **33.** Refrigerant is added to a centrifugal chiller through the ___ valve.

A. float

B. compressor service

C. condenser charging

D. evaporator charging

_______ **34.** When evacuating the refrigerant from a low-pressure chiller, the high-pressure cutout of the recovery machine is set for ___ psi.

A. 2

B. 5

C. 10

D. 15

_______ **35.** Chillers using CFC-11 and HCFC-123 require purge units because the ___.

A. purge unit removes dirt

B. chiller system operates below atmospheric pressure

C. purge unit removes refrigerant from the oil sump

D. purge unit removes CFCs from the chiller

_______ **36.** A device that removes air from the refrigerant of a centrifugal chiller refrigeration system during normal operation is called a ___.

A. pump-out

B. purge unit

C. ventilator

D. filter/dryer

_______ **37.** After system servicing, refrigerant vapor is reintroduced to the chiller refrigeration system before liquid refrigerant because ___.

A. vapor charging increases pressure slowly, preventing failure of the rupture disc

B. vapor charging is faster than liquid charging

C. liquid charging is more difficult to control than vapor charging

D. liquid refrigerant charged into a deep vacuum will boil and lower temperatures enough to freeze water in the chiller tubes

_______________ **38.** When using recovery and recycling equipment manufactured after November 15, 1993, technicians must evacuate low-pressure appliances to a level of ___ before disposing of the appliance.

A. 0 psi

B. 15″ Hg vacuum

C. 25″ Hg vacuum

D. 29″ Hg vacuum

_______________ **39.** R-123 falls under the ___ code group of ASHRAE Standard 34.

A. A1

B. A2

C. B1

D. B2

_______________ **40.** When removing oil from a low-pressure system, the compressor oil should be heated to 130°F because ___.

A. you can warm your hands on the container

B. less refrigerant will be contained in the oil at the higher temperature

C. warmer oil has a lower viscosity and flows more easily

D. it shows that the heater is working

_______________ **41.** Charged low-pressure refrigeration systems may be most efficiently leak checked by ___.

A. adding dry nitrogen

B. adding HCFC-22

C. operating the purge system

D. raising system pressure by heating with circulating hot water or a heating blanket

_______________ **42.** EPA regulations require that leaking commercial and industrial process refrigeration systems be repaired when the leak rate exceeds ___% of the charge per year.

A. 0

B. 15

C. 25

D. 35

_______________ **43.** The pressure corresponding to 32°F for R-123 is ___″ Hg vacuum.

A. 11

B. 17

C. 20

D. 23

_______________ **44.** Leak testing a low-pressure chiller with nitrogen in excess of 10 psi could cause the ___ to fail.

A. condenser tubes

B. purge unit shells

C. evaporator tubes

D. rupture disc

_______________ **45.** In an average 350 ton chiller with R-11 refrigerant at 0 psi pressure, ___ lb of refrigerant vapor may be left once all the R-11 liquid has been removed.

A. 20

B. 100

C. 500

D. 1000

______ 46. Low-pressure appliances need not be evacuated all the way to the prescribed level when ___.
A. the repair is major
B. the repair is followed by an evacuation of the appliance to the environment
C. leaks in the appliance make evacuation to the prescribed level unattainable
D. the appliance is being disposed of

______ 47. An oil sample should be taken when ___.
A. a new filter/dryer has been installed
B. the low-pressure system has had a compressor burnout
C. the low-pressure system is not cooling properly
D. recycled refrigerant has been added to the low-pressure system

______ 48. During evacuation of a low-pressure system with large amounts of moisture, it may be necessary to increase pressure with ___ to counteract freezing.
A. R-12
B. R-22
C. air
D. nitrogen

______ 49. The discharge from a rupture disc on a low-pressure chiller must be piped ___ for venting.
A. outdoors
B. inside the machinery room
C. to the evaporator
D. to the duct system

______ 50. Continuous excessive moisture collecting in the purge unit of a low-pressure refrigeration system indicates that the ___.
A. system was charged with contaminated refrigerant
B. condenser or chiller-barrel tubes are leaking
C. purge unit is not operating properly
D. purge adjustment is not set properly

______ 51. To prevent air accumulation into an idle low-pressure refrigeration system, ___.
A. leave the purge unit on line at all times
B. system pressure should be maintained slightly above atmospheric pressure
C. open the air vents on the condenser
D. intermittently operate the system with no load

______ 52. ASHRAE Standard 15-1994 requires that each machinery room shall activate an alarm and mechanical ventilation before refrigerant concentrations exceed the ___.
A. TLV-TWA (threshold limit value-time weighted average)
B. UTL (upper threshold limit)
C. COP (coefficient of performance)
D. EEL (emergency exposure limit)

______ 53. The ___ is/are particularly susceptible to leaks in low-pressure refrigeration systems with open drive compressors.
A. chiller tubes
B. shaft seal
C. charging connections
D. shaft bearings

_______________ **54.** ___ refrigerants are considered safe in terms of toxicity and flammability, but they require oxygen deprivation sensors.

A. A1
B. A3
C. B1
D. B3

_______________ **55.** ASHRAE Standard 15-1994 requires equipment room refrigerant sensors for the ___ safety group classification.

A. A1
B. B2
C. A2
D. all refrigerant safety groups

_______________ **56.** Excessive running of the purge unit on a low-pressure chiller generally indicates the ___.

A. air sensors are faulty
B. chiller system is leaking
C. ambient temperature is too low
D. efficiency of the purge unit is too low

_______________ **57.** Air in a low-pressure system is indicated by ___.

A. high head pressure
B. high liquid level
C. low head pressure
D. low suction pressure

_______________ **58.** Prior to recovering refrigerant from a chiller suspected of having leaking tubes, ___.

A. drain the water of the evaporator and condenser
B. run the circulating pumps
C. be certain the purge unit is operating
D. open the condenser vents

_______________ **59.** ___ does not fall under the EPA definition of "major maintenance, service, or repair."

A. Replacing an oil filter
B. Replacing the compressor
C. Re-tubing a heat exchanger (condenser)
D. Replacing a fin-and-tube forced air evaporator coil

_______________ **60.** Under EPA regulations, ___ can be circulated through to an R-11 or R-123 system for the purpose of opening the system for a nonmajor repair.

A. oxygen
B. hot water
C. compressed air
D. carbon dioxide

_______________ **61.** Pressure relief valves must not be installed ___.

A. in series
B. in parallel
C. vertically
D. horizontally

_______________ **62.** To remove ice from sight or viewing glasses, ___ should be used.

A. R-11 refrigerant
B. an alcohol spray
C. water
D. a screw driver

15

Canadian Regulations for Refrigerants

Canadian technicians who leak test, recover, evacuate, and charge systems must follow regulations and use service practices as dictated by the Environmental Code of Practice for the Elimination of Fluorocarbon Refrigerants from Refrigeration and Air Conditioning Systems published by Environment Canada. Provinces and territories typically refer to the local authority as either the Department of the Environment or Ministry of the Environment. There are proposed refrigerant regulations, to be voted on in Canada, that would be placed under federal jurisdiction if approved.

HALOCARBON REGULATIONS

Installation and service on equipment located in federally regulated lands must be performed in accordance with Environment Canada's federal halocarbon regulations. Individual provinces and territories may have their own halocarbon refrigerant handling guidelines. Technicians and anyone responsible for the handling of refrigerants and/or management of refrigerant-containing equipment are responsible for abiding by both federal and provincial/territorial regulations of where the work is being performed or where the equipment is located. It is the responsibility of the owner of the equipment and the technician to determine the appropriate jurisdiction and corresponding regulations.

As a result of the Labour Mobility Act, an environmental awareness card is valid province to province (territory), provided the individual has met the requirements of the regional director. The requirements of the specific province or territory must be verified prior to working on equipment within the region. The regulations are used to reduce the emissions of ozone-depleting and global warming substances into the environment.

DISCHARGE PROHIBITION

A Class I ozone-depleting substance or any material that contains a Class I ozone-depleting substance shall not be permitted to be discharged into the natural environment or environment within a building. As of January 1, 2015, equipment using a Class 1 ozone-depleting substance and that has a refrigeration capacity of greater than 19 kW = 5.4 tons = 64,828 Btu/hr = 25 hp is no longer permitted to operate on or in properties under federal jurisdiction.

Companies and technicians are not allowed to make, use, sell, transfer, display, transport, store, or dispose of a Class I ozone-depleting substances

Newfoundland and Labrador:
Regional Director
1-800-353-9089
Environmental Enforcement Division
Environment Canada
16th Floor, Queen Square
45 Alderney Drive
Dartmouth NS B2Y 2N6
Fax: 902-426-7924
Email:
FHR2003@ec.gc.ca

Technical Fact

Prince Edward Island, Nova Scotia, and New Brunswick:
Regional Director
1-800-565-1633
Environmental Enforcement Division
Environment Canada
16th Floor, Queen Square
45 Alderney Drive
Dartmouth NS B2Y 2N6
Fax: 902-426-7924
Email:
FHR2003@ec.gc.ca

Technical Fact

Quebec
Regional Director
Environmental Enforcement Division
1-866-283-2333
Environment Canada
105 McGill Street
(3rd Floor)
Montreal QC H2Y 2E7
Fax: 514-496-2087
Email: InstalFed.Dale-RQ@ec.gc.ca

Technical Fact

or any equipment that contains a Class I ozone-depleting substance. Also, a company or technician is not allowed to make, sell, or transfer any packaging, wrapping, or container that is made in a manner that uses a Class I ozone-depleting substance. **See Figure 15-1.**

Discharge of Refrigerants

A Class II ozone-depleting substance or halocarbon shall not be permitted to be discharged into the natural environment or the environment within a building. In the event that 100 kg (220 lb) or greater of a Class II ozone-depleting substance is discharged into the natural environment or within a building, the technician and the owner of the equipment must notify the Regional Ministry of the Environment as soon as reasonably possible after the discharge occurs. **See Figure 15-2.**

Ontario—Regional Director
1-800-268-6060
Environmental Enforcement Division
Environment Canada
845 Harrington Court
Burlington ON L7N 3P3
Fax: 905-333-3952
Email: FHR.Ontario@ec.gc.ca

CLASS I OZONE-DEPLETING SUBSTANCES

Chemical Name	Lifetime*	Formula	ODP†	GWP‡
GROUP 1				
CFC-11 Trichlorofluoromethane	45.0	CCl_3F	1.0	4600
CFC-12 Dichlorodifluoromethane	100.0	CCl_2F_2	1.0	10,600
CFC-113 Trichlorotrifluoroethane	85.0	$C_2Cl_3F_3$	0.8	6000
CFC-114 Dichlorotetrafluoroethane	300.0	$C_2Cl_2F_4$	1.0	9800
CFC-115 Chloropentafluoroethane	1700.0	$CClF_2$-CF_3	1.0	7200
GROUP 2				
Halon 1211 Bromochlorodifluomethane	11.0	CF_2BrCl	3.0	1300
Halon 1301 Bromotrifluoromethane	65.0	CF_3BrCl	10.0	6900
Halon 2402 1, 2-dibromotetrafluoroethane	–	$C_2F_4Br_2$	6.0	–

* years in atmosphere
† ozone depletion potential
‡ global warming potential

Figure 15-1. Class I ozone-depleting substances are materials that contain chlorine, fluorine, bromine, carbon, and hydrogen in varying proportions and are often described as halocarbons. They are the most threatening substances to the ozone layer.

CLASS II OZONE-DEPLETING SUBSTANCES

Chemical Name	Lifetime*	Formula	ODP†	GWP‡
HCFC-21 Dichlorofluoromethane	1.7	$CHFCl_2$	0.040	148
HCFC-22 Bromotrifluoromethane	65.0	CHF_2Cl	0.055	1780
HCFC-31 Monochlorofluoromethane	–	CH_2FCl	0.020	–
HCFC-225ca Dichloropentafluoropropane	1.9	$C_3HF_5Cl_2$	0.025	120

* years in atmosphere
† ozone depletion potential
‡ global warming potential

Figure 15-2. Class II ozone-depleting substances are materials known or reasonably expected to have harmful effects on the ozone layer and are often described as hydrochlorofluorocarbons (HCFCs).

Purge on Low-Pressure Chillers. Despite the prohibition on discharges, a technician may use or permit the use of a low-pressure chiller that discharges refrigerant. Today, through the use of high-efficiency purge units, chillers discharge no more than 0.1 kg of refrigerant per kilogram of air purged. **See Figure 15-3.** Due to the expense of regulated refrigerants, it would benefit a facility with low-pressure equipment (chillers) to invest in a high-efficiency purge unit to minimize any refrigerant released.

HIGH-EFFICIENCY PURGE UNIT DISCHARGE

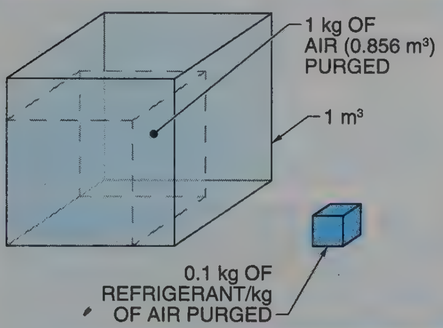

Figure 15-3. Purge units of the past discharged more refrigerant than air from systems. Today, purge units discharge about 0.1 kg of refrigerant for every kilogram of air purged.

Ozone-Depleting Substance Highlights

- *Fines upon convection for a technician releasing a Class I or Class II ozone-depleting substance or halocarbon into the natural environment or into the environment of a building may range from $5000 per day to $4,000,000 per day.*
- *Refrigerants subject to this regulation include Class I and Class II ozone-depleting substances and halocarbons.*
- *No one is allowed to discharge Class I or Class II ozone-depleting substances or halocarbons into the natural environment or into the environment of a building. Once a customer has been notified that a system is leaking, the customer must have the equipment repaired or the refrigerant recovered/isolated.*
- *Refrigerant losses of 100 kg or greater must be reported immediately to the Ministry of the Environment by the person responsible for the discharge (the customer when loss occurred before the technician arrived on site or the technician when the leak was caused by the work the technician was performing).*
- *Only ozone-depletion-potential- (ODP-) certified technicians that include 313A or 313D apprentice or C of Q or registered apprentice may service or test refrigerant-containing equipment.*
- *A refrigerant leak notice must include the technician's name, test date, ODP certificate number, expiration date, employer name and address, leak test results, and a statement that no refrigerant is to be added until the leak is repaired. A leak test tag cannot be removed unless it is being replaced with a new notice.*
- *All containers and systems that are being decommissioned must have notices on them stating that there is no refrigerant remaining along with a date, name, ODP card number/expiration date, and employer name.*
- *Recyclable/refillable containers may not go to a dump or landfilling site, and the containers must be tested every five (5) years.*
- *Only ODP-certified technicians may transfer refrigerant to and from containers/equipment.*
- *Out-of-province ODP cards are valid, providing the certificate holder satisfies the requirements of Certification in Use of Refrigerants and Refrigeration Systems.*
- *ODP certificates must be renewed every five (5) years. After failure to renew, certification requires the taking of a full-day course and successful completion of an exam.*

Servicing and Testing Refrigeration Equipment

A technician may not service or test refrigeration equipment that contains refrigerant unless the technician is certified to handle refrigerants and the technician or the employer owns equipment that is capable of collecting and capturing refrigerant. In some cases, the employer may have a written contract with a company that owns equipment that is capable of collecting and capturing refrigerant. The contract must provide for access to the equipment whenever needed.

Technicians must not use refrigerants to fill or refill refrigeration systems for the purpose of testing the systems. Technicians who test refrigeration systems that contain refrigerant to determine whether there is a leak in the equipment will conduct the test in accordance with the *Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.* **See Figure 15-4.**

When a technician tests refrigeration systems, the technician must give the

Manitoba, Saskatchewan, Alberta, Northwest Territories, and Nunavut
Regional Director
1-800-667-7525
1-800-222-6514
Environmental Enforcement Division
Environment Canada
Twin Atria Building
4999-98th Avenue NW, Room 200
Edmonton AB T6B 2X3
Fax: 780-495-2451
Email:
FHR2003.EED-PNR@ec.gc.ca

▶ Technical Fact

British Columbia and Yukon
Regional Director
1-800-663-3456
867-667-7244
Environmental Enforcement Division
Environment Canada
201-401 Burrard Street (4th Floor)
Vancouver BC V6C 3S5
Email:
FHR.PYR@ec.gc.ca

▶ Technical Fact

owner of the refrigeration equipment the test results. When the refrigeration equipment is part of the process of manufacturing a product containing a refrigeration system, special servicing and testing procedures apply.

RECORDS AND NOTICES

Technicians servicing and testing refrigeration equipment must promptly create records containing the following information:

- amounts and types of refrigerants purchased or obtained for the purpose of servicing or testing refrigeration equipment
- name of the refrigerant seller or supplier
- amount of any refrigerant discharge and an explanation for the discharge, regardless of whether the discharge occurred in the course of servicing or testing the equipment
- date of the service and testing, name of the technician performing the service or testing, and, if applicable, name of the technician's employer
- description of the service or testing being performed including the amount and type of refrigerant used, and types of refrigerant recaptured in the course of servicing and testing the equipment

Types of Refrigerants

Refrigerants are to be described using one of the terms for the specific ozone-depleting substance or halocarbon that the refrigerant is or contains. The terms are "Class I ozone-depleting substance," "Class II ozone-depleting substance," and "halocarbon."

ENVIRONMENTAL CODE OF PRACTICE FOR ELIMINATION OF FLUOROCARBON EMISSIONS FROM REFRIGERATION AND AIR CONDITIONING SYSTEMS BOOKLET

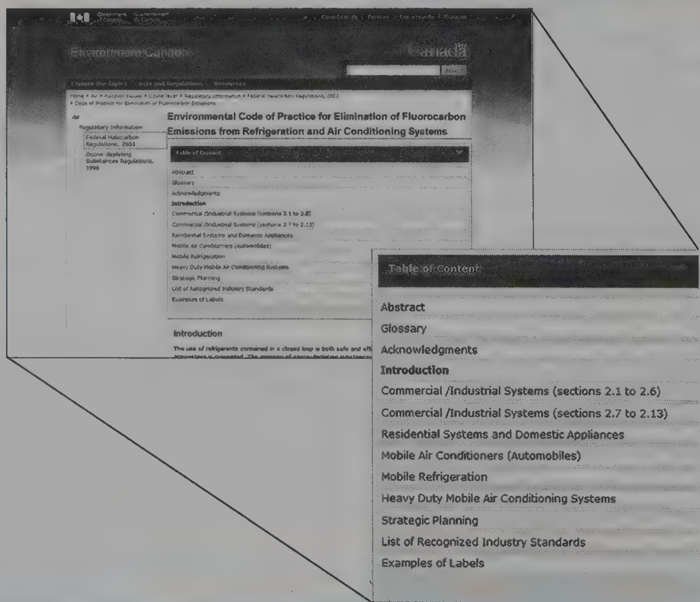

Figure 15-4. Technicians must test refrigeration and air conditioning systems for leaks per the regulations found in the *Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems* booklet.

Testing Notices

Any technician who tests refrigeration equipment to determine whether leaks are present will affix a notice to the equipment. **See Figure 15-5.** The notice will state the following:

- test date
- technician's name
- number and expiration date of the technician's certificate
- name of the technician's employer (when tests are performed in the course of employment)
- test results
- statement that refrigerant will not be added to the equipment until the leak is repaired (when there is a leak in the refrigeration equipment)

Testing Notice Record Keeping. Technicians must not remove the notice attached to equipment, except when attaching a new notice to the equipment. A copy of each notice affixed to the equipment must be kept for a period of two (2) years from the date of service or testing. The records of testing notices are to be kept by the employer of the technician who serviced or tested the refrigeration equipment, as long as the service or testing was performed as part of the technician's employment. When there is no employer, the technician or person who serviced the refrigeration system must store the records. When the refrigeration equipment is part of the process of manufacturing a product containing a refrigeration system, special servicing and testing procedures apply.

LEAK TESTING NOTICES

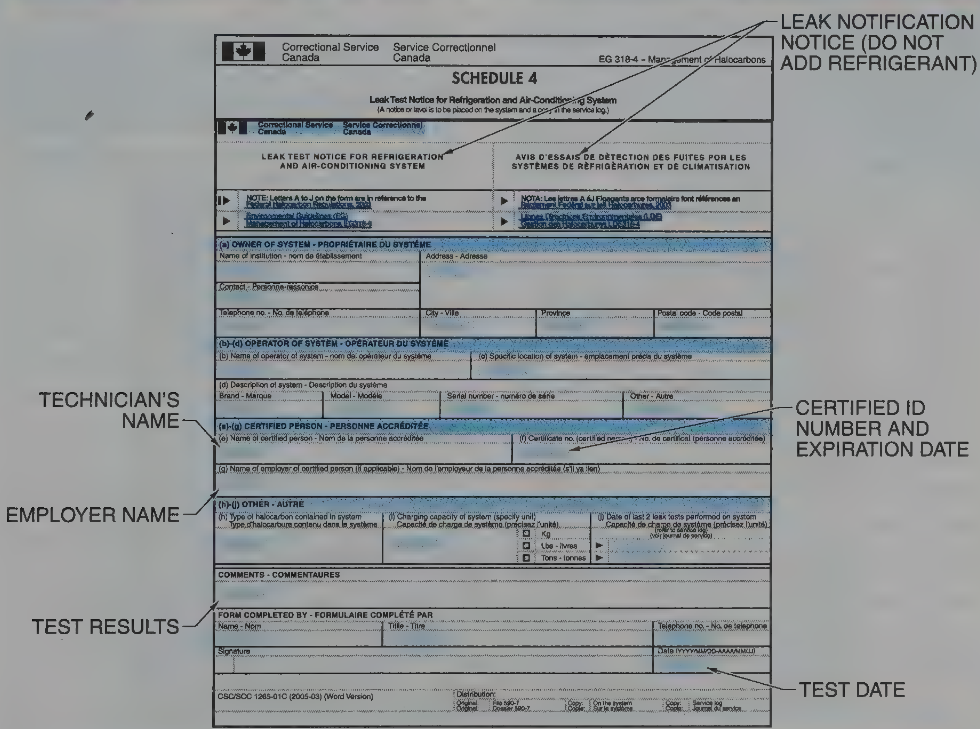

Figure 15-5. When systems are tested and/or leaks are repaired, technicians must affix a notice to the system that includes the test date, technician's name, number and expiration date of certificate, employer name, test results, and statement that no one can add refrigerant to the system until the leak is repaired, if applicable.

Paperwork, Records, and Notice Highlights

- *When completing records, paperwork, or documentation, technicians must include the refrigerant class name such as CFC-12, HCFC-22, HFC-134a, and HFC-410A.*
- *Natural refrigerants and pure hydrocarbons are not subject to this regulation.*
- *All low-pressure chillers must have high-efficiency purge units.*
- *Technicians must always have immediate access to refrigerant recovery equipment.*
- *Upon finding a leak within an HVAC system, a technician is responsible for immediately tagging the equipment with a notice and immediately notifying the customer.*
- *All technicians who service or test refrigerant-containing equipment must keep records of everything pertaining to refrigerant purchases, refrigerant leak tests, refrigerant leakage rates, reason for refrigerant loss from a system/container, refrigerant addition/installation, leak repairs, and the refrigerant type/quantities used.*
- *Provincial or territorial regulations may require as little as two years for record keeping, however federal halocarbon regulations require five years for record keeping. It is the technician's responsibility to know whether the equipment is deemed as federal or provincial/territory and the technician shall maintain records accordingly.*
- *Containers must be identifiable with regards to refrigerant type, refrigerant amount, and deposit amount. Also, they cannot be deposited at a dump or landfilling site.*
- *Renewal forms are available online at www.ualocal787.org or www.jtac787.org or at the JTAC office. Forms must be completed and faxed to the JTAC at least eight (8) weeks prior to the expiration of an existing certificate. After failure to renew, certification requires the taking of a full-day refrigerant handling certification course and successful completion of an exam.*
- *Federal halocarbon regulations continue to apply to facilities that are under federal jurisdiction. Federal Halocarbon Regulation 2003 is available online at the following site: Http:/lawslois.justice.gc.ca/eng/regulations/SOR-2003-289/page-1.html.*

The size of a small refrigeration system varies from federal to provincial/territory.
Federal=
19kW
5.4 ton
64,828 Btu/hr
25.5 hp
Provincial=
22kW
6.26 tons
75,134 Btu/hr
29.5 hp

▶ Technical Fact

Refilling Small Refrigeration Systems

Technicians must not use refrigerant to refill small refrigeration systems, except in accordance with set rules. A technician may use refrigerant to refill refrigeration equipment when the technician holds refrigerant handling certification and there is a notice on the refrigeration equipment that is not more than six (6) months old indicating that there are no leaks in the equipment. The technician must also verify that there is no apparent damage to the refrigeration system that may permit the discharge of refrigerant into the natural environment or within the environment of a building. A technician may also refill a system with refrigerant when there is no reasonable alternative and no immediate danger to human life or health, animal life, crops, plants, food stuffs, or the processing facility. **See Figure 15-6.**

REFILLING SMALL REFRIGERATION SYSTEMS

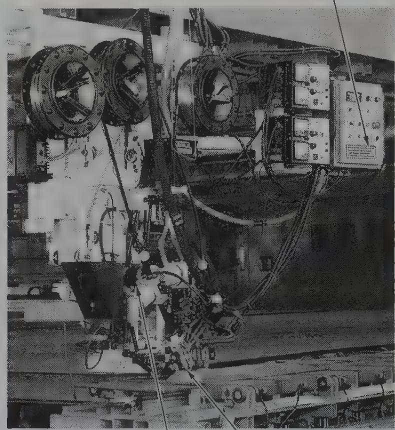

Figure 15-6. When there is no reasonable alternative to refilling a system with refrigerant, technicians may refill a system with refrigerant when certain immediate dangers do not exist.

Small Refrigeration System Owner of Responsibilities. When a technician refills a small refrigeration system and not all rules are followed, the owner of the equipment must promptly report the circumstances and the actions taken to the Director within seven (7) days. The owner must ensure that the refrigeration equipment is tested for leaks and that any leaks are repaired. The owner must also provide a report to the Director that includes the results of any testing, confirmation that any leaks found were repaired, and confirmation that a copy of the most recent notice affixed to the refrigeration equipment is placed in the equipment's permanent records. **See Figure 15-7.**

Refilling Large Refrigeration Systems

Technicians must not use refrigerants that contain a Class I ozone-depleting substance to refill large refrigeration systems that have one or more compressors with a total capacity of more than 22 kW. On or after January 1, 2012, no technician will use refrigeration equipment that contains a refrigerant that is or contains a Class I ozone-depleting substance. **See Figure 15-8.**

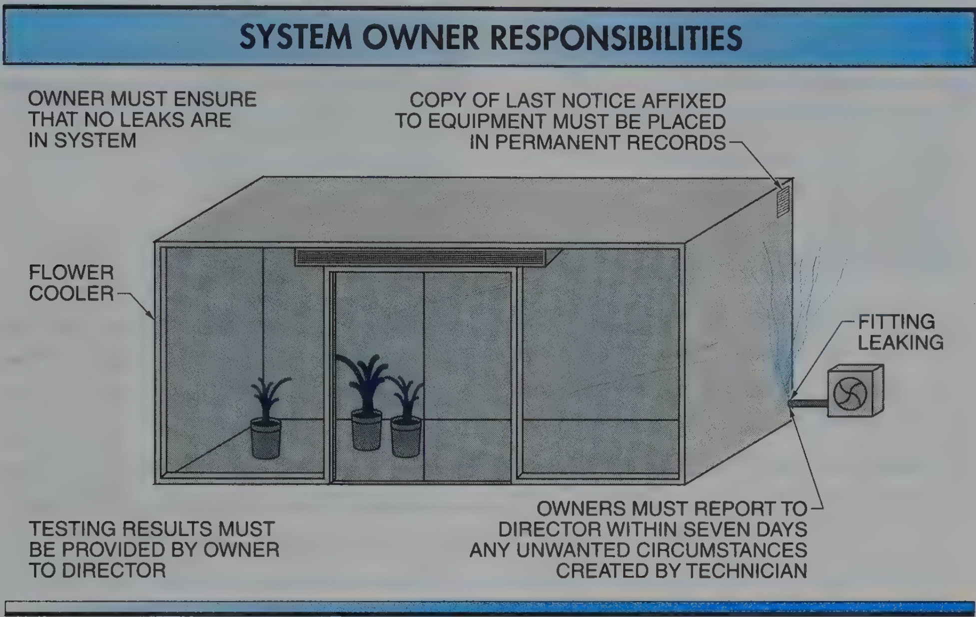

Figure 15-7. An owner must report to the Director within seven (7) days any work a technician performs on a system that does not follow regulations and keep a copy of the most recent notice on file permanently.

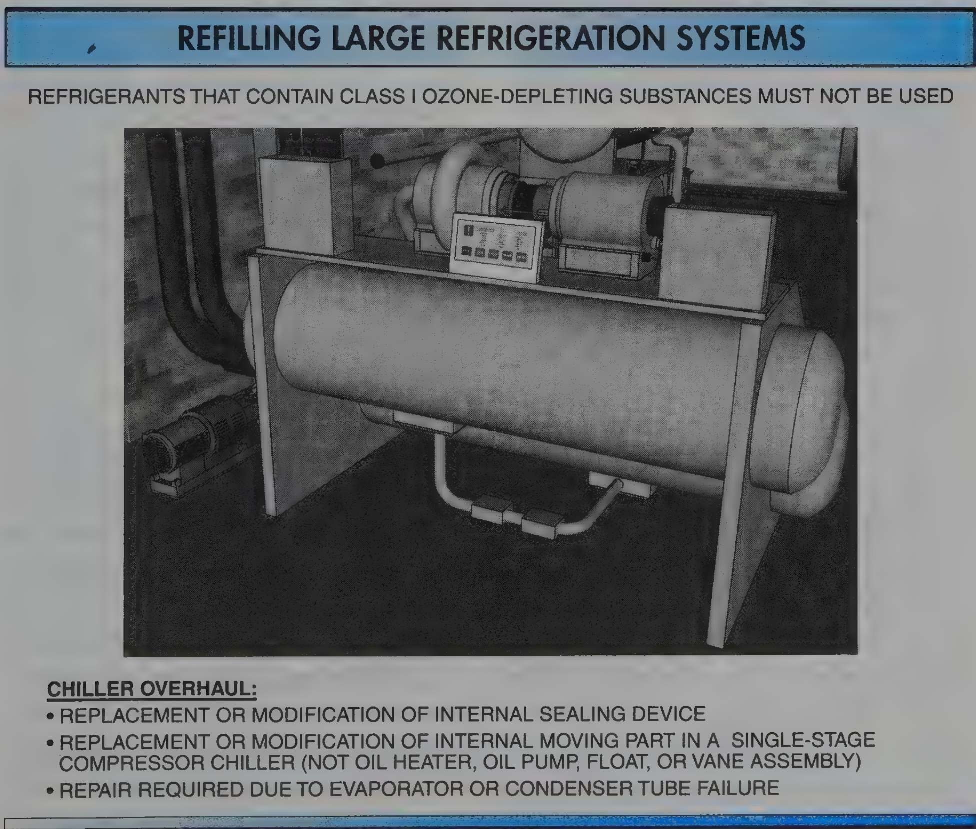

Figure 15-8. After January 1, 2012, technicians cannot use refrigeration equipment that contains a Class I ozone-depleting substance, including chillers that have had a major overhaul performed.

A major overhaul is the procedure used to repair a chiller and includes the following:

- replacement or modification of an internal sealing device in the chiller
- replacement or modification of an internal mechanical moving part in a single-stage compressor chiller other than the oil heater, oil pump, float assembly, or vane assembly
- repair required as a result of the failure of an evaporator or condenser heat exchanger tube

Owner Submittal Letters

Technicians cannot use a Class I ozone-depleting substance in a chiller that has had a major overhaul performed, except when the owner of the chiller has submitted a written notice to the Director. The written letter must include the following:

- a date no later than December 31, 2011, by which the owner intends to discontinue the use of the chiller so that a refrigerant that contains a Class I ozone-depleting substance is not being used
- whether the owner intends to discontinue the use of the chiller or convert the chiller so that it will not use a refrigerant that contains a Class I ozone-depleting substance

The owner of a chiller who submitted a written notice in accordance with set rules may submit a subsequent written notice to the Director that sets an alternate date that is no later than December 31, 2011, by which the owner plans to discontinue the use of a chiller with Class I ozone-depleting substances. The subsequent letter may also specify whether the owner intends to convert the chiller to a non-Class I ozone-depleting substance.

On or after January 1, 2012, a company or technician cannot use a Class I ozone-depleting substance in a chiller that has been through a major overhaul. When a technician uses a refrigerant that is or contains a Class I ozone-depleting substance to refill a chiller before January 1, 2012, the technician has within seven (7) days after the refilling to provide written notice to the Director setting out the date by which the chiller will be retrofitted with a non-Class I ozone-depleting substance.

Filling Containers

Certified technicians are allowed to use refrigerants to fill containers, other than refrigeration equipment, that are designed to hold and prevent the discharge of Class I and Class II ozone-depleting substances and halocarbons. Technicians must use recycle/refillable containers (recovery cylinders). **See Figure 15-9.**

Every container containing refrigerant must have a label. The labels on cylinders containing refrigerant must include notice that the container contains an ozone-depleting substance, identify the refrigerant inside the container, state that the container is recyclable and refillable, state that the container can be returned to the seller for a minimum refund of $25, and state that the container cannot be disposed of by depositing in a dump or landfilling site.

Sale or Transfer of Refrigerants

A certified technician can sell or transfer refrigerant to another certified technician to service refrigeration equipment or when the refrigerant is in a refrigeration system where any of its parts are being sold or transferred. A technician may sell or transfer refrigerant in a container when the refrigerant was acquired for the purpose of resale.

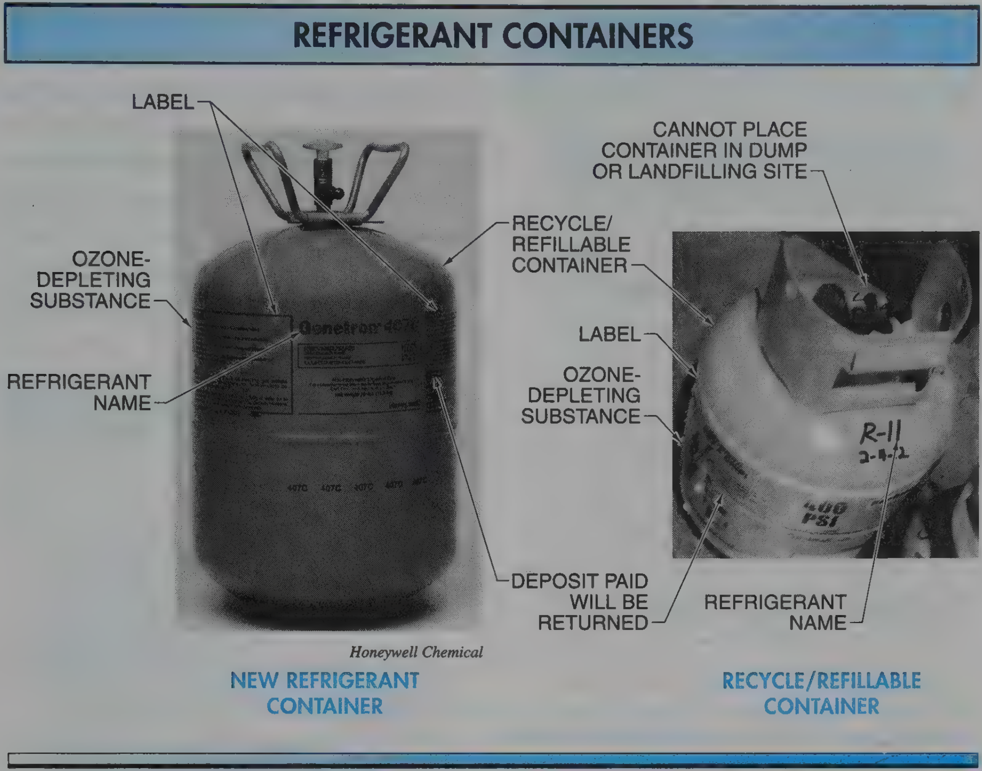

Figure 15-9. Technicians must use recyclable/refillable containers with labels indicating the type of refrigerant or ozone-depleting substance contained. The container label must also state the deposit amount.

Deposits and Refrigerant Sales Records

Certified sellers sell refrigerant in containers and must charge a deposit of at least $25 for the container (cylinder) at the time of the sale. People who sell refrigerant in containers must accept every used container that they sold and will pay to the person presenting the container the amount of the deposit that was charged for the container at the time of the sale.

Refrigerant sellers must keep a record of every sale of refrigerant, which is to include the date of sale, amount and type of refrigerant, and the name of the certified technician who purchased the refrigerant. **See Figure 15-10.** The purchaser certification number and expiration date also must be recorded. When the purchaser is an employee of the certified person, the ID number and expiration date of the certified person's certificate must be recorded. All sellers must keep a record of the sale for a period of two (2) years from the date of the sale. The requirements for paperwork and records for the sale of refrigerant, deposit on refrigerant containers, and transfer of refrigerants do not apply when refrigerant is deposited directly into a tank vehicle or refrigeration equipment.

A person who sells refrigerant in a container shall charge a deposit of at least $25 for the container at the time of sale, accept every used container sold by the seller, and pay to the person presenting the container the amount of the deposit that was charged for the container at the time of sale. The person who sold the refrigerant in a container shall promptly create a record of the sale.

> Technical Fact

REFRIGERANT SELLER RECORD KEEPING

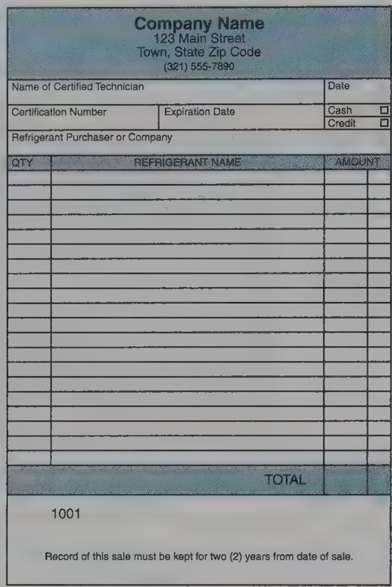

Figure 15-10. Sellers of refrigerant must keep a record of the ozone-depleting substance sold, the purchaser, and the technician's certification card number and expiration date.

Notices Indicating No Refrigerant

A technician certified in the use of refrigerants and refrigeration equipment may determine that refrigeration equipment or a container that has contained refrigerant no longer contains refrigerant. In this case, the technician must affix a notice to the refrigeration equipment or container that states the date of termination, technician's name, ID number and expiration date of the certificate, and name of the technician's employer as well as a statement that the refrigeration equipment or container no longer contains any refrigerant. A copy of the notice must be kept for a minimum of two (2) years. **See Figure 15-11.**

CERTIFICATION IN THE USE OF REFRIGERANTS AND REFRIGERATION EQUIPMENT

A technician qualifies for a refrigerant authorizing certificate when the technician has successfully completed a course approved by the Director that provides training and testing in the use and handling of ozone-depleting substances, halocarbons, refrigerants, and refrigeration equipment. The Director will ensure that information about the approved course is made available to the public on the ministry's website and by such other means as the Director considers appropriate.

NO REFRIGERANT NOTICE

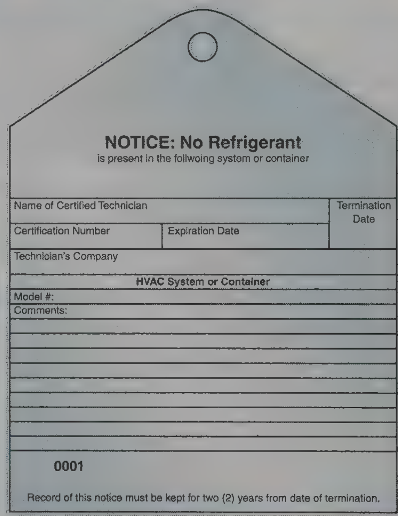

Figure 15-11. When a system/container no longer contains refrigerant, a notice must be affixed to the system/container stating that it no longer contains any refrigerant.

Issuing Authorizing Certificates

The Director will renew the certificate of a technician when the technician makes a request for renewal before the expiration date on the certificate and pays any required fees. The certificate will include the name of the technician who holds the certificate, certificate ID number, and an expiration date.

A certificate is valid for five (5) years from the date of issue. The Director may refuse to issue or renew a certificate or may revoke a certificate issued to a technician if the past conduct

of the technician affords reasonable grounds to believe that the technician will not comply with the requirements of the regulation. When the Director proposes to refuse to issue or renew a certificate or to revoke a certificate, the Director will give written notice to the technician setting out the reasons for the proposal and informing the technician that he or she may make written submissions to the Director within 30 days after the date of the notice. After considering any written submissions, the Director will do one of the following:

- refuse to issue the certificate
- revoke the certificate
- issue the certificate
- refrain from revoking the certificate

A technician who holds an authorizing certificate issued by an out-of-province regulatory authority qualifies for a certificate under certain conditions. **See Figure 15-12.** These conditions are as follows:

- the technician provides the Director with a copy of the authorizing certificate
- the certificate to be issued, in the opinion of the Director, is in respect to the same occupation as the technician's authorizing certificate
- the technician provides the Director with confirmation in writing from the out-of-province regulatory authority that the authority issued the technician's authorizing certificate, the certificate is not expired, and the certificate has not been cancelled or revoked
- the technician provides the Director with a signed statement that the technician has obtained the training material for the course mentioned and that the technician is knowledgeable about the legislation and regulations that govern the use and handling of ozone-depleting substances, halocarbons, refrigerants, and refrigeration equipment in Ontario

To purchase and handle refrigerants in Canada, a technician is required to have an ozone depletion prevention (ODP) certificate card. The technician must complete a one-day course, receive a mark of 75% or greater, and pay a fee. Once completed, the card will be issued by the Ministry of the Environment.

Technical Fact

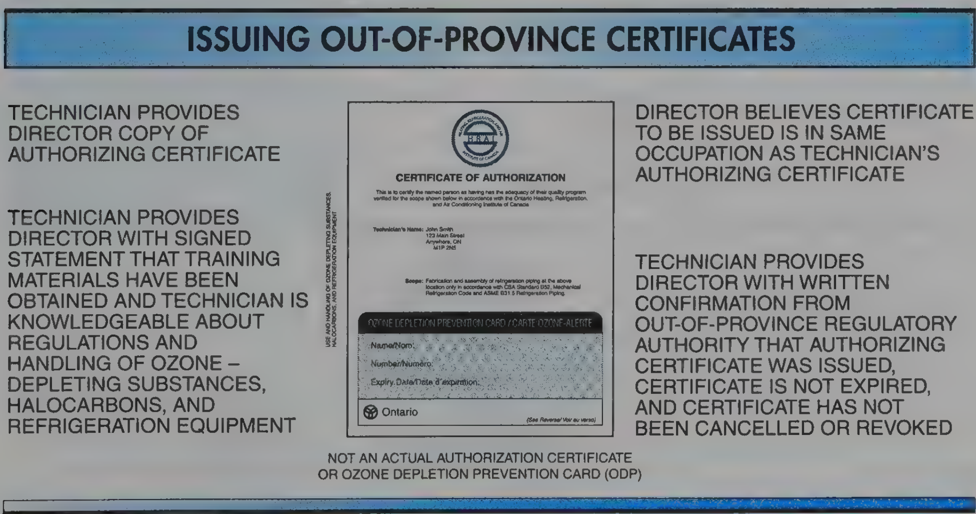

Figure 15-12. A technician can acquire an authorizing certificate if an out-of-province certificate can be proven to be in good standing.

POSSESSION OF REFRIGERANT BEFORE AND AFTER JANUARY 1, 2012

When immediately before January 1, 2012, a technician is in possession of a refrigerant that is or contains a Class I ozone-depleting substance and that was collected from refrigeration equipment, the technician will, no later than July 1, 2012, deliver the refrigerant to a wholesaler who sells or distributes refrigerants. When on or after January 1, 2012, a technician collects refrigerant that is or contains a Class I ozone-depleting substance from refrigeration equipment, the technician will, within six (6) months after the refrigerant was collected, deliver the refrigerant to a wholesaler who sells or distributes refrigerants. **See Figure 15-13.**

On application, the Director may extend the time within which a technician is required to deliver a refrigerant to a wholesaler who sells and distributes refrigerants. When the Director is satisfied that, for reasons beyond the technician's control, the technician is unable to deliver the refrigerant to the wholesaler within the time required, extra time may be allowed. A person who is required to deliver a refrigerant to a wholesaler will deliver it in a container typically referred to as a recycle/refillable container.

Delivery of Refrigerants that Contain a Class I Ozone-Depleting Substance

When a technician delivers a refrigerant that is or contains a Class I ozone-depleting substance to a wholesaler who sells or distributes refrigerants, the wholesaler will accept the refrigerant at no charge. This rule does not apply unless the refrigerant is transferred to the wholesaler in a recycle/refillable container at the wholesaler's normal place of business during normal business hours. **See Figure 15-14.**

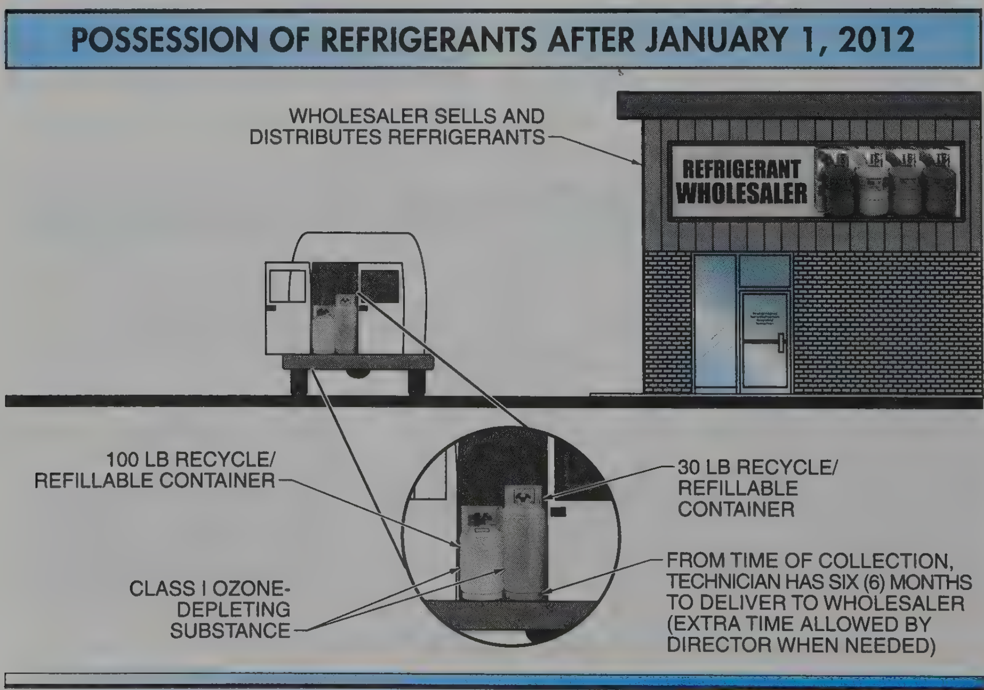

Figure 15-13. Technicians must deliver to a refrigerant wholesaler any ozone-depleting substances captured within six (6) months of being collected. It is possible for the Director to allow time extensions.

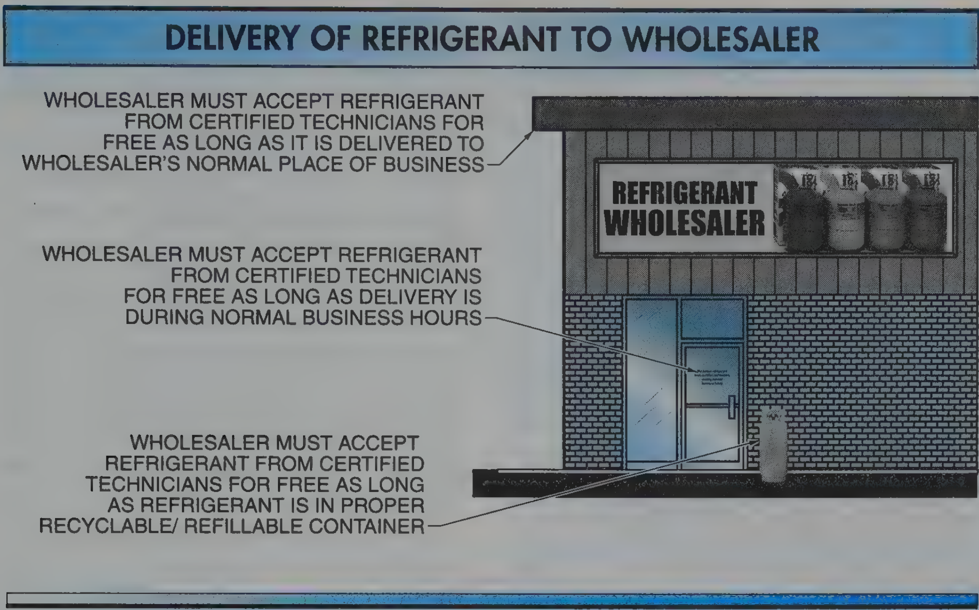

Figure 15-14. Technicians must deliver ozone-depleting substances to wholesalers in acceptable recyclable/refillable containers at the wholesaler's normal place of business during normal business hours.

Transfer, Transport, Storage, or Disposal of Ozone-Depleting Substances as Waste

The regulation does not prohibit or restrict the transfer or transport of or anything that contains a Class I or Class II ozone-depleting substance that is waste to a waste management system or to or from a waste disposal site as permitted under the act. **See Figure 15-15.** Certain substances, including the following, are designated as waste material:

- a solvent or sterilant that contains a Class I or Class II ozone-depleting substance, other than a solvent or sterilant used, stored, or transferred
- refrigerant that is or contains a Class I ozone-depleting substance and that has been collected from refrigeration equipment on or after July 1, 2012
- substances designated as waste when they are or were hazardous waste within the meaning of Regulation 347 of the Revised Regulations of Ontario, 1990 (General-Waste Management) made under the act

Also, nothing in the regulation prohibits the storage or disposal of or anything that contains a Class I or Class II ozone-depleting substance at a waste disposal site.

Fire Extinguishing Equipment and Containers

A technician will not dismantle, destroy, recycle, incinerate, or dispose of in a dump or landfilling site fire extinguishing equipment that contains Halon™ in an amount of more than 3 kg unless a notice has been affixed to the equipment and the equipment is handled in a manner authorized under the act. A technician will not dismantle, destroy, recycle, incinerate, or dispose of in a dump or landfilling site a container referred to as recycle/refillable unless a notice has been affixed to the container and the container is handled in a manner authorized under the act. This regulation does not apply to the dismantling that takes place in the course of the manufacture of a product that is or contains refrigeration equipment. **See Figure 15-16.**

CLASS I AND CLASS II SUBSTANCES AS WASTE

Class I Substances	Class II Substances
Methyl chloroform	HCFC-21 (dichlorofluoromethane)
Carbon tetrachloride	HCFC-22 (chlorodifluoromethane)
CFC-11 (trichlorofluoromethane)	HCFC-23 (chlorofluoromethane)
CFC-12 (dichlorodifluoromethane)	HCFC-121 (tetrachlorofluoroethane)
CFC-13 (chlorotrifluoromethane)	HCFC-122 (trichlorodifluoroethane)
CFC-111 (pentachlorofluoroethane)	HCFC-123 (dichlorotrifluoroethane)
CFC-112 (tetrachlorodifluoroethane)	HCFC-124 (chlorotetrafluoroethane)
CFC-113 (trichlorotrifluoroethane)	HCFC-221 (hexachlorofluoropropane)
CFC-114 (dichlorotetrafluoroethane	HCFC-225 (dichloropentafluoropropane)
CFC-115 (chloropentafluoroethane)	HCFC-235 (chloropentafluoropropane)
All other CFCs	HCFC-241 (tetrachloropluoropropane)
All isomers and CFC mixtures	HCFC-242 (trichlorodifluoropropane)
Halon-1211 (bromochlorodifluoromethane)	HCFC-253 (chlorotrifluropropane)
Halon-1301 (bromotrifluoromethane)	HCFC-271 (chlorofluoropropane)
Halon-2402 (dibromotrifluoroethane)	All other hydrochlorofluorocarbons
Chlorocarbons	All HCFC mixtures

Figure 15-15. Solvents, sterilants, and Class I and Class II ozone-depleting substances are considered waste materials.

FIRE EXTINGUISHING EQUIPMENT AND CONTAINERS

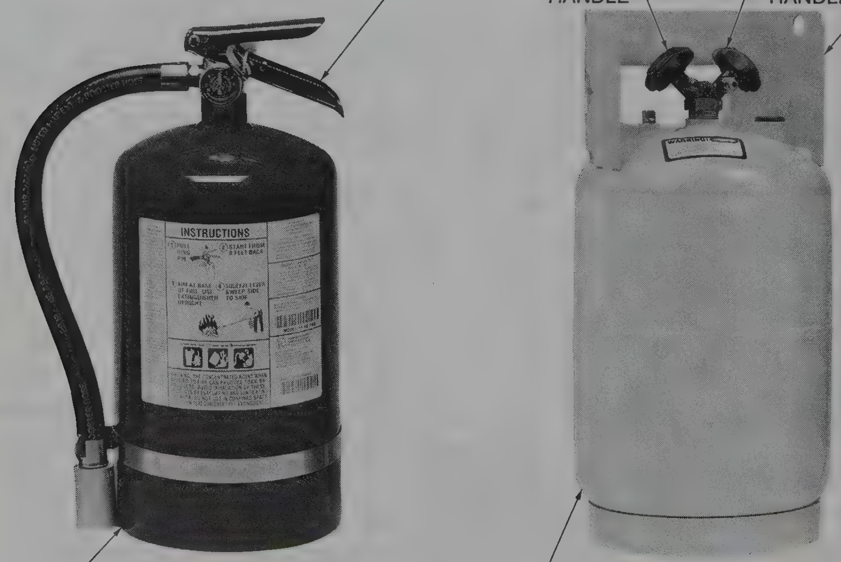

Figure 15-16. Fire extinguishing equipment containing 3 kg or more of Halon cannot be placed in a dump or landfilling site without being dismantled or destroyed and having a notice affixed.

Disposal of Portable Fire Extinguishers Designed to Contain Less than Three Kilograms of Halon

A technician may dismantle, destroy, recycle, incinerate, or dispose of by depositing in a dump or landfilling site a portable fire extinguisher designed to contain Halon in an amount of 3 kg or less in a manner authorized under the act. Even though small amounts of Halon can be disposed of by the technician, the technician should use every precaution possible to keep the Halon from entering the environment. Halon has a higher ozone depletion potential than chlorofluorocarbons. Halon is used mainly for fire suppression systems. When the Halon system is removed, another type of fire suppression system is chosen to replace it.

USE OF REFRIGERANTS IN MOTOR VEHICLE AIR CONDITIONERS

A technician may not use, in a motor vehicle that requires a permit under the Highway Traffic Act, a motor vehicle air conditioner that contains a refrigerant that is or contains a Class I ozone-depleting substance unless the air conditioner was installed in the motor vehicle on or before December 31, 1994. A technician may not use a refrigerant that is or contains a Class I or Class II ozone-depleting substance to fill or refill a motor vehicle air conditioner, regardless of whether the motor vehicle requires a permit under the Highway Traffic Act. Despite the purpose of testing a motor vehicle air conditioner, a technician may use a refrigerant that is or contains a halocarbon to fill or refill the air conditioner in accordance with the Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.

Class I Ozone-Depleting Substance Highlights

- *Class I refrigerants include chlorofluorocarbons (CFCs), Halons, carbon tetrachloride, methyl chloroform, and hydrobromofluorocarbons (HBFCs). Class I refrigerants include any mixture containing any of these substances or any isomer (different molecular arrangement) of these substances.*
- *Class I CFCs include, but are not limited to, CFC-11, CFC-12, CFC-13, CFC-113, CFC-114, CFC-115, CFC-500, CFC-502, and CFC-503.*
- *Halocarbon refrigerants include any fluorocarbon (FC), hydrofluorocarbon (HFC), or any mixture that may contain any of these substances or any isomer of these substances.*
- *Halocarbon HFCs include, but are not limited to, HFC-23, HFC-32, HFC-125, HFC-134a, HFC-404A, HFC-407A, HFC-407C, HFC-410A, HFC-507, and HFC-508.*
- *Class I, Class II, and halocarbon refrigerants may not be added to a system for the purpose of leak testing.*
- *Refrigeration systems with a capacity greater than 22 kW (6.25 tons) may not have Class I CFCs added.*
- *Low-pressure chillers may not have Class I CFCs added unless the equipment meets the accepted exemptions according to the regulations.*
- *Class I CFC-containing equipment of greater than 22 kW and Class I CFC-containing chillers will not be allowed to operate on or after January 1, 2012. These systems must be either replaced or converted to non-Class I refrigerants in order to operate.*
- *As of January 1, 2012, any recaptured Class I CFC must be returned to a wholesaler at no cost to the technician.*
- *As of July 1, 2012 recovered Class I CFCs are hazardous waste.*

Yellow Jacket Div., Ritchie Engineering Co., Inc.

A person must not use a refrigerant that is or contains a Class I or Class II ozone-depleting substance to fill or refill a motor vehicle air conditioner, regardless of whether the motor vehicle requires a permit under the Highway Traffic Act.

Class II Ozone-Depleting Substance Highlights

- *Class II refrigerants include hydrochlorofluorocarbons (HCFCs) and any mixture containing or isomer of HCFCs.*
- *Class II HCFCs include, but are not limited to, HCFC-22, HCFC-123, HCFC-124, HCFC-401, and HCFC-409.*
- *Class I, Class II, and halocarbon refrigerants may not be added to a system for the purpose of leak testing.*

Proposed Canadian federal ODP regulations are under consideration. All provinces and territories will have to follow the new federal regulations. These proposed regulations can be referenced using the access code or QR Code at the end of the chapter.

Technical Fact

Servicing and Testing Motor Vehicle Refrigeration Systems

A technician who tests mobile refrigeration equipment or a motor vehicle air conditioner to determine whether a leak exists may affix a notice to the frame or edge of the door nearest to the driver's seat. **See Figure 15-17.** Mobile refrigeration equipment is equipment that is installed in, normally operates in or in conjunction with, or is attached to a means of transportation but does not include a motor vehicle air conditioner.

SERVICING AND TESTING MOTOR VEHICLE REFRIGERATION SYSTEMS

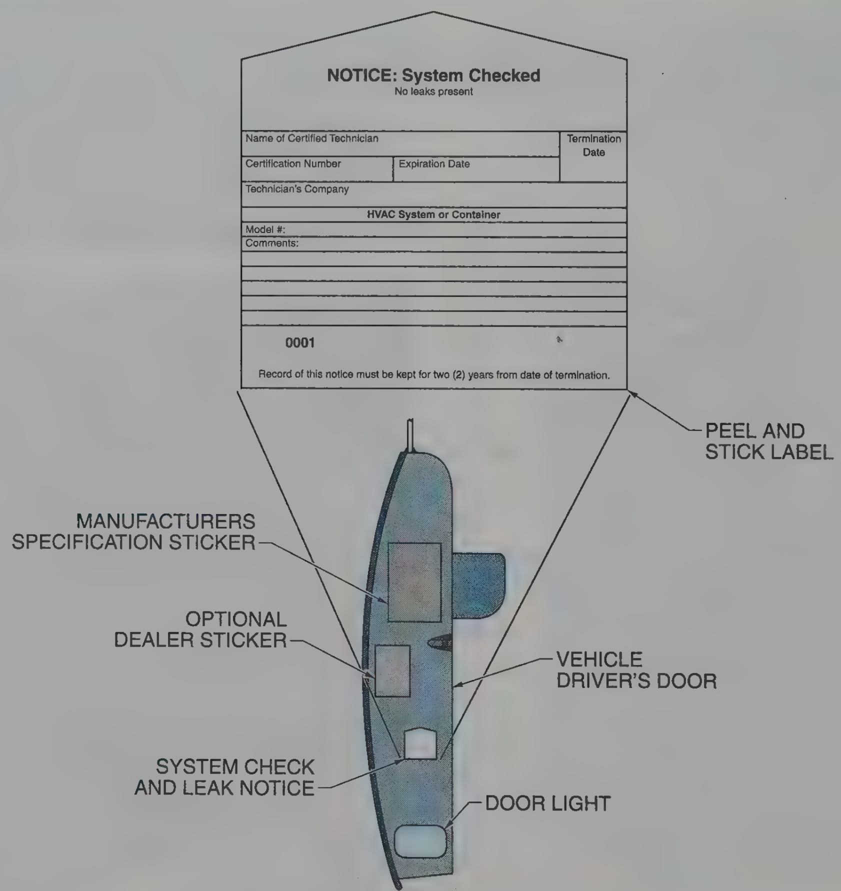

Figure 15-17. Any leaking motor vehicle air conditioning and refrigeration system must have a notice affixed to the system or driver's door.

Discussion Questions

1. Why may not a technician permit a discharge of Class I and Class II refrigerants and any substance that contains a Class I or Class II substance into the natural environment?
2. What must a technician give to the owner of refrigeration equipment once testing is complete?
3. How are refrigerants to be described?
4. What information must be placed on a leak testing notice that is affixed to refrigeration equipment by a technician after testing?
5. How can a technician use refrigerant to refill refrigeration equipment?
6. What must the owner of refrigeration equipment do when a technician does not follow regulations when working on refrigeration equipment?
7. What must a technician do after filling a recycle/refillable container with recovered refrigerant?
8. What information must the seller record when a technician purchases refrigerant?
9. What must a technician do when equipment or a container does not contain any refrigerant?
10. How does a technician with an out-of-province authorized certificate acquire a certification card?
11. What must a technician do to successfully deliver refrigerant to a refrigerant wholesaler?
12. How must a technician process a Halon fire extinguisher for disposal?

Digital Resources
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Proposed Federal ODP Regulations
ATPeResources.com/QuickLinks
Access Code: 827847

REVIEW QUESTIONS

Name ______________________ Date ______________

______ **1.** Technicians who leak test, recover, evacuate, and charge HVAC systems in Canada must follow regulations and use service practices dictated by the ___.

A. Heating, Refrigeration, and Air Conditioning Institute of Canada
B. owner of the equipment
C. Director of the Ministry of the Environment
D. Canadian Standards Association

______ **2.** A technician who discharges or permits to be discharged an excessive amount of a Class I or Class II ozone-depleting refrigerant into the natural environment or within the environment of a building must report the fact ___.

A. within 1 day
B. within 1 week
C. within 1 month
D. as soon as reasonably possible

______ **3.** When a technician tests a refrigeration system, the technician must give the test results to the ___.

A. Heating, Refrigeration, and Air Conditioning Institute of Canada
B. owner of the equipment
C. Director of the Ministry of the Environment
D. Canadian Standards Association

______ **4.** A copy of each notice attached to HVAC equipment must be kept for a period of ___ from the date of service or testing.

A. six months
B. one year
C. two years
D. five years

______ **5.** A technician may use refrigerant to refill refrigeration equipment when the technician holds refrigerant handling certification and there is a notice on the refrigeration equipment that is not more than ___ old indicating that there are no leaks in the equipment.

A. six months
B. one year
C. two years
D. five years

______ **6.** When a technician refills a small refrigeration system and not all rules are followed, the owner of the equipment must promptly report the circumstances and the actions taken within ___.

A. one day
B. seven days
C. two weeks
D. one month

______ **7.** On or after ___, no technician will use refrigeration equipment that contains a refrigerant that is or contains a Class I ozone-depleting substance.

A. July 6, 1999
B. December 31, 2011
C. January 1, 2012
D. July 1, 2012

_______________ **8.** The owner of a chiller who submitted a written notice in accordance with set rules may submit a subsequent notice to the ___ that sets an alternate date that is no longer than December 31, 2011, by which the owner plans to discontinue the use of a chiller with a Class I ozone-depleting substances.

A. Director

B. Commissioner

C. Government of Canada

D. Heating, Ventilating, and Air Conditioning Institute of Canada

_______________ **9.** Technicians must use ___ to recover refrigerant.

A. disposable cylinders

B. recovery cylinders

C. empty new refrigerant containers

D. recycle/refillable containers

_______________ **10.** Certified sellers who sell refrigerants in containers must charge a deposit of at least ___ for the container at the time of the sale.

A. $10

B. $25

C. $50

D. $100

_______________ **11.** Information concerning refrigerant handling certification classes are available on the ___ website.

A. Heating, Refrigeration, and Air Conditioning Institute

B. government of Canada Correctional Services

C. Ministry of the Environment

D. Canadian Standards Association

_______________ **12.** An ODP card is valid for ___ years from the date of issue.

A. 2

B. 3

C. 5

D. 10

_______________ **13.** Once a technician has collected a Class I or Class II ozone-depleting substance from refrigeration equipment, the technician will, within ___ after the refrigerant was collected, deliver the refrigerant to a wholesaler who sells or distributes refrigerants.

A. three months

B. six months

C. one year

D. two years

_______________ **14.** The regulation does not prohibit the storage or disposal of or anything that contains a Class I or Class II ozone-depleting substance at a ___ site.

A. waste disposal

B. refrigerant reclamation

C. refrigerant seller

D. refrigerant recycling

_______________ **15.** A technician who tests mobile refrigeration equipment or a motor vehicle air conditioner to determine whether a leak exists may affix a notice to the ___.

A. compressor

B. frame or edge of door nearest to the driver's seat

C. hood

D. radiator cowling

16

Canadian Regulations for Refrigerants Certification Test Questions

One hundred questions are found on a typical universal certification test. The information covered by the universal test includes 25 questions each of core, Class I, Class II, and halocarbon information.

Name ______________________________ Date ______________

______________ **1.** ___ is the process being performed when refrigerant is removed from an HVAC system without any filtering or moisture mediation.

A. Reclaiming
B. Recycling
C. Recovery
D. Evacuation

______________ **2.** ___ is the element in refrigerants that causes ozone depletion.

A. Fluorine
B. Chlorine
C. Carbon
D. Bromine

______________ **3.** ___ refrigerants were the first refrigerants to be banned from production, on December 31, 1995.

A. PFC
B. HFC
C. HCFC
D. CFC

______________ **4.** ___ refrigerant is the most harmful to the ozone layer.

A. R-12
B. R-22
C. R-134a
D. R-407C

_______ 5. ___ are fluorocarbon refrigerants that cause no harm to stratospheric ozone.
- A. CFCs
- B. HCFCs
- C. HFCs
- D. Halons

_______ 6. Refrigerant ___ is the type of contamination that is the most difficult for a reclaiming facility to eliminate.
- A. with air
- B. with moisture
- C. from an acid burnout
- D. containing particulate matter

_______ 7. The ozone layer protects the planet's surface from ___.
- A. losing oxygen
- B. UV radiation
- C. chlorine monoxide
- D. greenhouse gases

_______ 8. Class I, Class II, and Halon ozone-depleting substances are subject to refrigerant ___ regulations.
- A. HRAI
- B. ASCII
- C. seller
- D. handling

_______ 9. One of the most serious results of damage to the ozone layer is ___.
- A. increased growth of marine plants and plankton
- B. increased volcanic activity
- C. increases in the occurrence of human skin cancer
- D. decreased ground level ozone

_______ 10. It is estimated that one chlorine molecule can destroy over ___ ozone molecules before finally leaving the stratosphere.
- A. 100
- B. 1000
- C. 10,000
- D. 100,000

_______ 11. ___ is a chlorine-free refrigerant.
- A. HFC-134a
- B. CFC-11
- C. HCFC-22
- D. CFC-12

_______ 12. Refrigerant losses of ___ or greater must be reported immediately to the Ministry of the Environment by the person responsible for the discharge (the customer when the loss occurred before the technician arrived on site or the technician when the leak was caused by the work of the technician).
- A. 1 g
- B. 10 kg
- C. 50 kg
- D. 100 kg

_______________ **13.** ___ is an HCFC refrigerant.

A. R-11
B. R-22
C. R-114
D. R-717

_______________ **14.** ___ is an HFC refrigerant.

A. R-11
B. R-22
C. R-115
D. R-134a

_______________ **15.** Technicians who face fines, lose their ODP card certification, and must appear in federal court have violated ___.

A. HRAI provisions
B. provisions of the Clean Air Act
C. Correctional Services of Canada provisions
D. provisions of the Refrigerant Handling Act

_______________ **16.** Canada and the United States agreed that CFCs will not be manufactured after ___.

A. 1990
B. 1996
C. 2000
D. 2012

_______________ **17.** ASHRAE refrigerant safety classification standard Class ___ refrigerants are the most dangerous (higher flammability and higher toxicity).

A. A1
B. A3
C. B1
D. B3

_______________ **18.** The system component that changes low-pressure vapor refrigerant to high-pressure vapor refrigerant is the ___.

A. thermal expansion valve
B. compressor
C. condenser
D. evaporator

_______________ **19.** A technician must not discharge or permit the discharge of a ___ or any material that contains a ___ into the natural environment or the environment within a building.

A. Class I and Class II ozone-depleting substance
B. noncondensable substance
C. inert gas such as dry nitrogen
D. compressor oil

_______________ **20.** Any technician who discharges or permits to be discharged ___ kg or more of an ozone-depleting substance must report the incident.

A. 0.1
B. 1
C. 10
D. 100

_______________ **21.** When required, the release of ozone-depleting substances must be reported to the ___.

A. Ministry of the Environment
B. Heating, Refrigeration, and Air Conditioning Institute of Canada
C. Correctional Service of Canada
D. Environment of Canada's inquiry centre

_______________ **22.** Most high-efficiency purge units used with low-pressure chillers discharge ___ kg of refrigerant with every kilogram of air purged.

A. 0.1
B. 1
C. 10
D. 100

_______________ **23.** Technicians who test refrigeration systems that contain refrigerant to determine whether there is a leak must conduct the test in accordance with the ___.

A. Correctional Service of Canada codes
B. Heating, Refrigeration, and Air Conditioning Institute of Canada regulations
C. Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems regulations
D. Ontario Management of Refrigerants standards

_______________ **24.** When a technician tests a refrigeration system, the technician must give the test results to the ___.

A. Ministry of the Environment
B. owner of the refrigeration equipment
C. Heating, Refrigeration, and Air Conditioning Institute of Canada
D. Correctional Service of Canada

_______________ **25.** Technicians who test refrigeration equipment to determine whether a leak exists must affix a ___ to the equipment.

A. refrigerant MSD sheet
B. notice
C. safety mask
D. lockout device

_______________ **26.** After testing a system for leaks, a copy of the test results must be kept for a period of ___ years from the date of the service or testing.

A. 2
B. 3
C. 5
D. 10

_______________ **27.** A technician may use refrigerant to refill refrigeration equipment when the technician holds refrigerant handling certification and there is information on the equipment that is not more than ___ old, which indicates that there are no leaks in the equipment.

A. one month
B. two months
C. six months
D. one year

_______________ **28.** Before refilling a small refrigeration system, the technician must verify that ___ the system.

A. there is no apparent damage to
B. nitrogen is being charged into
C. all valves are closed on
D. pressure is low in

_______________ **29.** When a technician fills a small refrigeration system and all the rules are not followed, the owner of the equipment must promptly report the circumstances and the actions taken to the ____.

A. facility manager
B. maintenance manager
C. Heating, Refrigeration, and Air Conditioning Institute
D. Director

_______________ **30.** When a technician fills a small refrigeration system and all the rules are not followed, the owner has ____ to report the actions of the technician.

A. 7 days
B. 2 weeks
C. 1 month
D. 6 months

_______________ **31.** Technicians must not use refrigerants that contain a Class I ozone-depleting substance to refill large refrigeration systems that have one or more compressors with a total capacity of more than _____.

A. 7.5 kW
B. 22 kW
C. 300 psi
D. 400 psi

_______________ **32.** Technicians cannot use a Class I ozone-depleting refrigerant or substance in a chiller that has had a major overhaul performed, except when the owner has submitted ____ to the Director.

A. an approved written notice
B. maintenance logs
C. manufacturer specifications
D. warning labels

_______________ **33.** Technicians must use ____ to store recovered refrigerant.

A. throw away cylinders
B. recycle/refillable containers
C. new manufacturer cylinders
D. empty, new refrigerant containers

_______________ **34.** Every container containing refrigerant must have a ____.

A. hose
B. pressure gauge
C. label
D. safety lock

_______________ **35.** Certified sellers sell refrigerants in containers and must charge a minimum deposit of ____ for the container at the time of the refrigerant sale.

A. $10
B. $25
C. $50
D. $75

_______________ **36.** Certified sellers must keep a record of the sale of refrigerant for a period of ____.

A. three months
B. six months
C. one year
D. two years

________ **37.** A technician may determine that refrigeration equipment or a container that once contained refrigerant no longer contains refrigerant and must affix a(n) ___ to the equipment.

A. letter from the Minister

B. HRAI card

C. refrigerant tag

D. notice

________ **38.** An ODP card is valid for ___ years.

A. 2

B. 5

C. 7

D. 10

________ **39.** Technicians who hold an authorizing certificate issued by an out-of-province regulatory authority qualifies for a certificate when the director is provided with a copy of the technician's nonexpired or revoked certificate and the ___.

A. technician submits a $100 fee

B. certificate to be issued is, in the opinion of the Director, in the same occupation as the technician's authoring certificate

C. Director is provided with the technician's ODP card number

D. Heating, Refrigeration, and Air Conditioning Institute of Canada forms are received

________ **40.** When, on or after January 1, 2012, a technician collects a refrigerant that is or contains a Class I ozone-depleting substance from refrigeration equipment, the technician has ___ after the refrigerant was collected to deliver the refrigerant to a wholesaler.

A. one month

B. two months

C. six months

D. one year

________ **41.** When a technician delivers a Class I ozone-depleting substance to a wholesaler, the wholesaler will accept the refrigerant ____.

A. at no charge

B. for a $50 charge

C. for a $100 charge

D. as deposit on a new container

________ **42.** Wholesalers do not have to accept refrigerant when the refrigerant is ___.

A. in a recycle/refillable container

B. delivered to the wholesaler's normal place of business

C. delivered during normal business hours

D. a mixture of refrigerants

________ **43.** ___ is not designated as waste material.

A. A solvent containing a Class 1 ozone-depleting substance

B. A sterilant containing a Class I ozone-depleting substance

C. A Class I refrigerant collected after July 1, 2012,

D. R-134a

________ **44.** Fire extinguishing equipment that is designed to contain Halon in a quantity of more than ___ kg cannot be deposited in a dump or landfilling site without a special notice.

A. 0.1

B. 0.5

C. 1

D. 3

_______________ **45.** Halon has a higher ozone depletion potential than ____.

A. hydrochlorofluorocarbons
B. chlorofluorocarbons
C. hydrofluorocarbons
D. perfluorocarbons

_______________ **46.** After testing a motor vehicle air conditioner to determine whether a leak exists, the technician may affix the test information to the ____ nearest to the driver's seat.

A. door handle
B. window handle
C. edge of the door
D. coat hanger

_______________ **47.** Before disposing of any appliance with CFC or HCFC refrigerants, the technician must ____.

A. evacuate the system
B. recover the refrigerant
C. seal the refrigeration system
D. sign off on the record sheet

_______________ **48.** Recycle/refillable containers must be tested every ____ years.

A. 2
B. 5
C. 10
D. 15

_______________ **49.** The typical replacement for refrigerant R-12, with system modifications, is ____.

A. R-134a
B. R-407c
C. R-410A
D. R-512

_______________ **50.** Refrigerant enters the metering device of a refrigeration system as a ____.

A. liquid
B. frozen solid
C. low-pressure vapor
D. high-pressure vapor

17 Certification Test Preparation

The EPA certifies technicians, contractors, and distributors for handling refrigerants. The purpose of the certification tests is to ensure that individuals are qualified to sell, recover, recycle, charge, and/or transport refrigerants, and maintain proper documentation.

REFRIGERANT CERTIFICATION TESTS

Refrigerant certification tests and certifying agencies are overseen by the EPA. Certifying agencies may also have specific certification test requirements that include items such as registration fees and specific types of identification. A refrigerant certification test consists of a variety of multiple choice questions. Practicing with sample certification test questions will help prepare technicians for taking an EPA-approved refrigerant certification test.

To pass a refrigerant certification test, knowledge of EPA standards and refrigerant handling practices must be acquired. In addition, new refrigerant recovery and recycling equipment that technicians must use is continually being developed. New skills must be continually acquired to remain current with advancing technology and to grow in the air conditioning and refrigeration profession. The ability to adapt as the industry changes is crucial for a technician's continued success. **See Figure 17-1.**

Apprentices attending school, technical update seminars, and company classes, or participating in professional organization activities, receive valuable information on current refrigerant topics and trends.

For example, the International Union of Operating Engineers (IUOE) requires apprentices to take classes and acquire a refrigerant certification card before graduating. Many local refrigeration license requirements, such as in New York City, will use technician certification as a qualification to take the local license examination.

Environmental Protection Agency

The *Environmental Protection Agency (EPA)* is a government agency that protects human health and the environment. Since 1970, the EPA has been working for a cleaner, healthier environment for the American people.

REFRIGERANT TECHNICIAN SKILLS

Figure 17-1. Refrigerant technicians must continually acquire new skills to remain current with advancing technology and to grow in the air conditioning and refrigeration profession.

The EPA leads the nation's environmental science, research, education, and assessment efforts. The EPA also develops and enforces regulations (standards) enacted by Congress, offers financial assistance to state environmental programs, performs environmental research to assess environmental conditions, identifies future environmental problems, sponsors voluntary partnerships and programs such as minimizing greenhouse gases, and furthers environmental education.

The certified refrigerant technician is a professional who must be familiar with information pertaining to refrigerants and refrigerant handling equipment. **See Figure 17-2.** Sources of information include operation manuals, technical bulletins, government documents, and industry standards. EPA standards (industry standards) are periodically revised to reflect changes in the air conditioning and refrigeration industry.

Congress, with the Federal Registry, publishes the Clean Air Act (Title VI-*Stratospheric Ozone Protection*). The sections of Title VI of interest to refrigerant technicians are Section 601–*Definitions,* Section 602–*Listing of Class I and Class II Substances,* Sections 604 and 605–*Phase-out of Class I and Class II Substances,* and Section 608–*National Recycling and Emission Reduction Program*. Another source for refrigerant technician information is the Air Conditioning and Refrigeration Institute (ARI).

Air Conditioning and Refrigeration Institute

The *Air Conditioning and Refrigeration Institute (ARI)* is a national trade association representing 90% of all North American manufacturers producing air conditioning and refrigeration equipment. The standards and procedures developed and published by the ARI are used for measuring and certifying air conditioning and refrigeration equipment performance. By using the ARI criteria, products are rated on a uniform basis, so that technicians and engineers can properly make selections for specific applications. Many ARI standards are accepted as standards by the American National Standards Institute (ANSI).

REFRIGERANT TECHNICIAN CERTIFICATION

A certified refrigerant technician has passed a core information test

and one or more certification tests. A *Refrigerant Transition and Recovery Certification card* is an ID card that documents that the holder is qualified to safely recover, recycle, charge, and purchase or sell refrigerants. Information about refrigerant certification can be obtained from the EPA, ARI, or other EPA-authorized testing companies and organizations. **See Figure 17-3.**

Certification Requirements

Certifying agencies have specific requirements specifying that persons must pass with a 72% (80% mail-in Type I) on the core test, and on one or more of the Type I, Type II, or Type III tests. Registration fees, identification, and proof of passing prior tests may be required by a certifying agency.

Certification Classifications

Certification classification varies with the type of air conditioning or refrigeration system refrigerant to be used. For example, a small appliance with R-12 refrigerant requires a passing grade on a 25-question core test and a passing grade on a 25-question Type I test. The core information test is a prerequisite to taking the Type I, Type II, and Type III tests. A universal test has the core information as part of the test. The EPA divides the tests into four different parts:

1. Core Information (prerequisite to Type I, Type II, and Type III tests)
2. Small Appliances (Type I)
3. High-Pressure Equipment (Type II)
4. Low-Pressure Equipment (Type III)

The EPA also has four different refrigerant certifications:

1. Small Appliance certification (Type I) requires passing core and Type I tests.
2. High-Pressure certification (Type II) requires passing core and Type II tests.
3. Low-Pressure certification (Type III) requires passing core and Type III tests.
4. Universal certification requires passing core, Type I, Type II, and Type III tests.

REFRIGERANT AND REFRIGERANT EQUIPMENT INFORMATION

REFRIGERANTS

Refrigerant ASHRAE No.	Type	Evaporator Pressure	Safety Group	Application
R-12	CFC	High-medium	A1	Small reciprocating and rotary
R-22	HCFC	High	A1	Medium positive-displacement
R-123	HCFC	Low	B1	Large centrifugal

RECOVERY, RECYCLING, RECHARGING UNIT

Specifications

Voltage	115V 60 Hz
Refrigerant Container	30 lb on board
Operating Range	50°F to 120°F
Filter/Dryer	43 cu in. in-line
Pump Displacement	3 cfm
Dimensions	50″ H × 34″ W × 23″ D
Shipping Weight	225 lb

Manual Air Purge:	Remove air from internal storage container. Gauges show when to purge air.
Electronic Scale:	Mounted internally for protection, with dampening mechanism to protect against impact shocks.
Internal Storage Container:	Permanently mounted to scale.
Unit of Measure:	Select pounds or kilograms.

Figure 17-2. A certified refrigerant technician must be familiar with refrigerants and refrigerant handling equipment.

SECTION 608 TECHNICIAN CERTIFICATION PROGRAMS*

U.S. Environmental Protection Agency
Section 608 Technician Certification Programs at web address www.epa.gov

Section 608 Technician Certification Programs
Programs appearing on this list are approved to provide the EPA technician certification test. The EPA does not review or approve any training preparatory programs or materials. Many programs offer testing locations throughout the country.

For further information concerning section 608 of the Clean Air Act, or any other issue related to stratospheric ozone protection, or to obtain copies of regulations or fact sheets, call the Stratospheric Ozone Information Hotline.

Technician Certification Programs	Additional Information
Air-Conditioning Heating & Refrigeration Institute (ARI) 2111 Wilson Blvd Suite 500 Arlington, VA 22201 (703) 524-8800	Fee: $45.00 training materials available approved: 9/30/93
Operating and Maintenance Engineer Trade Training Trust Fund for California and Nevada 2501 W. Third Street Los Angeles, CA 90057 (213) 385-2889	Fee: $45.00 $50.00 for test and training training available approved: 10/13/13

* The EPA list includes 86 other schools, companies, and organizations

Figure 17-3. Information about refrigerant certification can be obtained from the EPA, ARI, or other EPA-authorized testing companies and organizations.

The four levels of certification dictate the curriculum (equipment) covered and the requirements for taking the certification tests. For example, a universal certification requires that the technician pass a 100-question universal certification test containing 25 core questions, 25 Type I questions, 25 Type II questions, and 25 Type III questions. A universal certification represents that the technician taking the test received at least 18 correct answers out of the 25 questions in each group.

Certification Test Preparation

Certification test preparation is determined by the type of certification desired. Certification tests vary in cost and question content. For example, the 25 questions for a Type I certification test come from a bank of questions on small appliances. A certifying agency typically provides a list of recommended study materials for preparing for a certification test. General suggestions for certification test preparation include the following:

- Learn as much as possible about the test. Obtain information from the certifying agency about the test. Talk with individuals who have successfully passed the test. Verify that the test is the correct test (core, Type I, Type II, Type III, or universal) for the certification expected. **See Figure 17-4.**
- Test preparation should be paced. Research the topics covered on the test. Develop a study schedule and focus on specific topics one at a time over an extended period of time.
- Review test study materials over several days prior to the test. Any review of the material the night before the test should be limited.

- If unfamiliar with the test location, drive to the site a few days before the test date.
- Schedule a normal amount of sleep the night before the test.
- Allow ample time for traveling to the test site.

Completing Certification Tests

General suggestions for completing the multiple-choice certification tests include the following:

- Avoid being intimidated and remain calm. The necessary preparation for the test has been completed, and now, that preparation will ensure the expected results. **See Figure 17-5.**
- After receiving the test, assess the amount of time available to complete it. On the first pass through the questions, answer only the questions that can be answered with absolute certainty. Pace your work according to the time allotted for each section.
- If a question is skipped, be sure to skip that number on the answer sheet.
- Read each question carefully and identify all possible answers. Know what is being asked before attempting to answer a question. Take time to verify that the proper answer blank has been filled in completely.
- On answer sheets to be scanned by a machine, correctly fill in the space on the answer sheet as instructed. Erase any changes completely.
- If unsure of an answer, lightly mark the question number on the answer sheet. When finished with the other questions, return to the unanswered question and, if still unsure after checking the question again, eliminate the obvious incorrect answers. Make an educated guess using the remaining answers. Avoid picking the same letter on three consecutive questions; it is possible, but typically rare, for three consecutive questions to have the same answer. Never leave an unanswered question.
- Beware of doubting your initial choice. Do not outguess yourself and change a correct answer to a wrong one. Never change an answer unless you are absolutely sure that the new answer is the correct one.

When finished with the examination, review the entire test or answer sheet for any missing information or answers, misplaced answers, or stray marks. The number of answers completed on the test or answer sheet must match the number of questions.

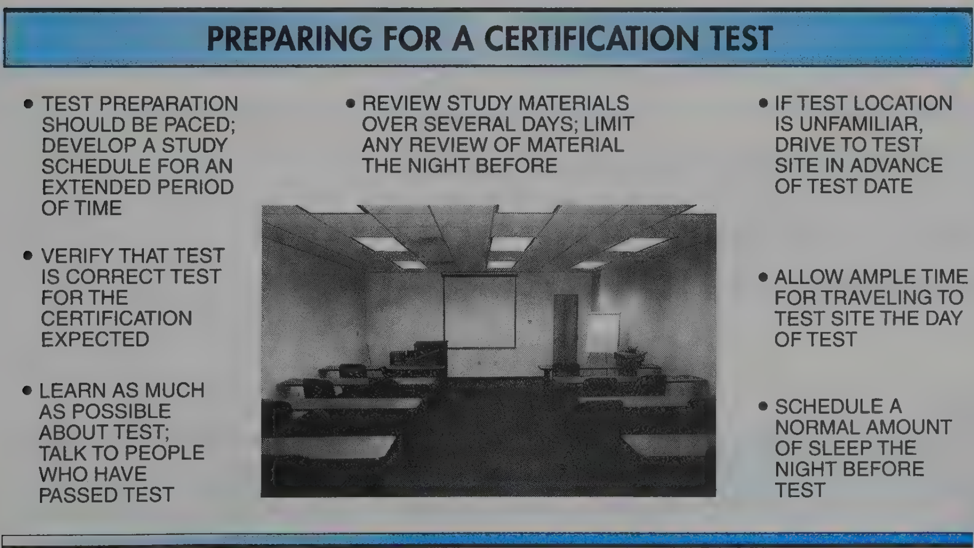

Figure 17-4. Technicians following general suggestions on how to prepare for a refrigerant certification test are more likely to pass the test on the first attempt.

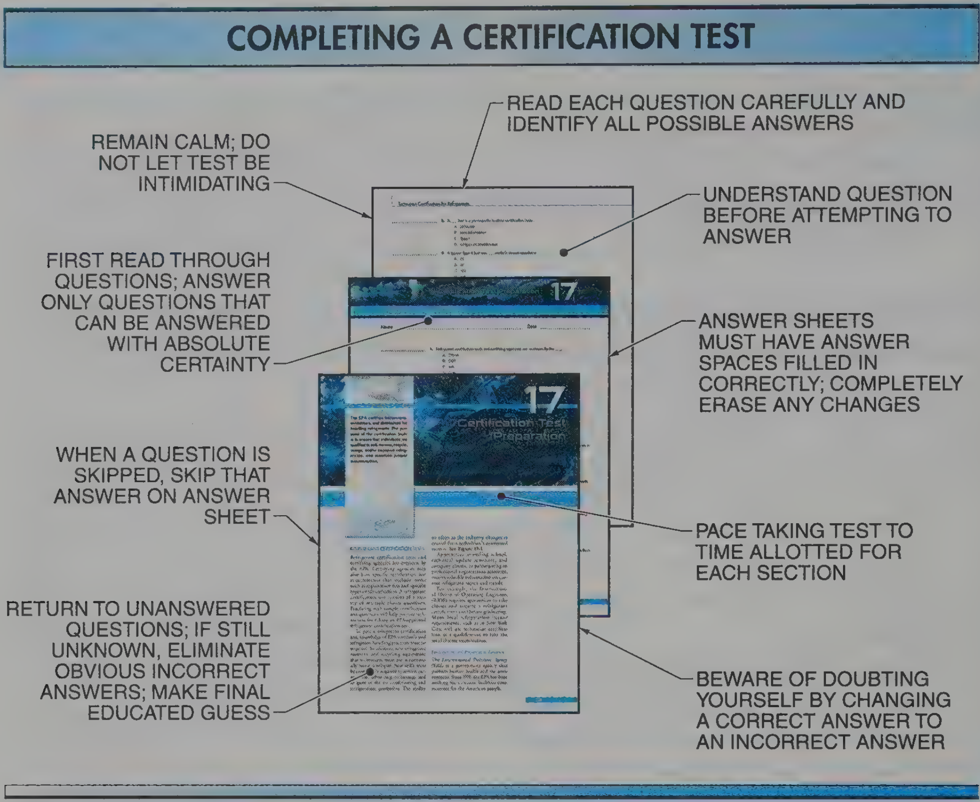

Figure 17-5. Technicians following general suggestions on how to take a refrigerant certification test are more likely to pass the test on the first attempt.

Discussion Questions

1. How does a certified refrigerant technician stay up to date with changes in the air conditioning and refrigeration industry and EPA standards?
2. How does the ARI assist technicians working in the air conditioning and refrigeration industry?
3. How can a technician acquire information about refrigerant technician certification?
4. What scores are required for passage of certification tests?
5. How does the EPA classify certification tests?
6. How many questions are typically found on a test for universal certification?
7. What are some general suggestions for preparing to take certification tests?
8. What should be done if a certification test question cannot be answered?

Digital Resources

ATPeResources.com/QuickLinks
Access Code: 827160

REVIEW QUESTIONS

Name ______________________ Date ______________

______________ **1.** Refrigerant certification tests and certifying agencies are overseen by the ___.

A. OSHA

B. DOT

C. ARI

D. EPA

______________ **2.** Since 1970, the EPA has been working for a ___ for the American people.

A. less regulated workplace

B. friendlier environment

C. safer workplace

D. cleaner and healthier environment

______________ **3.** The Clean Air Act (Title VI) Section 608–___ is of importance to refrigerant technicians.

A. *Listing of Class I Substances*

B. *Definitions*

C. *National Recycling and Emission Reduction Program*

D. Significant New Alternatives Policy (SNAP)

______________ **4.** The Air Conditioning and Refrigeration Institute is a ___ representing 90% of all manufacturers in North America producing air conditioning and refrigeration equipment.

A. government agency

B. trade association

C. state society

D. show organization

______________ **5.** By using ARI criteria, ___ are rated on a uniform basis, so that proper selections can be made.

A. technicians

B. certification tests

C. state required certification laws

D. refrigeration products

______________ **6.** A(n) ___ is an ID that documents that the holder is qualified to safely recover, recycle, charge, and purchase or sell refrigerants.

A. federal refrigerant card

B. refrigerant transition and recovery certification card

C. air conditioning diploma

D. refrigerant license

______________ **7.** A person taking a certification test must receive a score of ___% to receive a passing grade from a certifying agency.

A. 60

B. 68

C. 72

D. 85

______ 8. A ___ test is a prerequisite to other certification tests.
- A. universal
- B. core information
- C. Type I
- D. refrigerant identification

______ 9. A typical Type II test has ___ multiple choice questions.
- A. 25
- B. 50
- C. 100
- D. 125

______ 10. Prior to taking a certification test, persons should review materials ___.
- A. intensively the night before the test
- B. intensively the day of the test
- C. over several days
- D. at different times of the day

______ 11. If unfamiliar with the testing location, ___ before the test date.
- A. call the testing agency for directions
- B. acquire a map of the testing city
- C. talk to friends for directions
- D. visit the site a few days

______ 12. On the first pass through taking a certification test, ___.
- A. answer only the questions that can be answered with absolute certainty
- B. answer only every other question
- C. answer only the questions that deal with Chapter 1
- D. skim through each of the questions

______ 13. If a question is skipped on a certification test, the technician ___.
- A. is allowed to skip 5 questions
- B. must skip that number on the answer sheet
- C. can request a replacement question
- D. should not guess the answer

______ 14. If unsure of an answer, ___.
- A. mark all possible answers
- B. make an immediate educated guess
- C. mark any answer
- D. return to the question and eliminate obvious incorrect answers

______ 15. When finished with the test, review the entire test for ___.
- A. any blank spots that are supposed to be blank
- B. any stray marks
- C. changes in answers
- D. anything until the time is up

18 Universal Certification Test Questions

One hundred questions are found on a typical universal certification test. The information covered by the universal test includes 25 questions each of core, Type I, Type II, and Type III information.

Name ______________________ Date ______________

CORE INFORMATION

Questions 1 through 25

______ **1.** Chlorine from ___ rains out of the troposphere and does not reach the stratosphere.
- A. volcanoes
- B. ozone
- C. carbon monoxide
- D. manufacturers

______ **2.** A condenser changes ___ to a ___ in a refrigeration system.
- A. high-pressure vapor; low-pressure liquid
- B. high-pressure vapor; high-pressure liquid
- C. high-pressure liquid; low-pressure vapor
- D. low-pressure liquid; high-pressure vapor

______ **3.** Depletion of the ozone layer affects the environment by increasing ___.
- A. plant growth
- B. the amount of flowers that bloom
- C. the body mass of humans
- D. low-level ozone

______ **4.** An increase in UV radiation could result in an increase of ___.
- A. fertility
- B. cataracts cases
- C. marine organism growth
- D. rain

______________________ **5.** Ozone molecules are destroyed by the ___ atom of a CFC molecule.

A. fluorine

B. carbon

C. chlorine

D. oxygen

______________________ **6.** The ozone layer protects the planet surface from ___.

A. losing oxygen

B. chlorine monoxide

C. UV radiation

D. hydrogen chloride

______________________ **7.** Besides recovery and recycling, supplies of CFC refrigerants since 1995 for equipment servicing come from ___.

A. hydrated refrigerant

B. refrigerant sellers

C. wholesalers

D. reclamation facilities

______________________ **8.** On July 1, 1992, it became illegal to ___.

A. use CFC or HCFC refrigerants

B. manufacture CFC or HCFC refrigerants in the U.S. or import them

C. knowingly release CFC or HCFC refrigerants in the U.S. or import them

D. charge CFC refrigerants into a system

______________________ **9.** ___ of an air conditioning or refrigeration system is accomplished by evacuating the system to the required finish vacuum and holding the vacuum to remove moisture.

A. Pressurization

B. Initialization

C. Dehydration

D. Evacuation

______________________ **10.** A safety precaution that must be followed is to never use___.

A. piercing valves

B. piston pump recovery machines

C. canvas gloves around refrigerants

D. oxygen to purge lines or pressurize a system

______________________ **11.** Technicians who violate the provisions of the ___ can be fined, forced to appear in court, and lose their certification card.

A. Clean Air Act

B. Montreal Protocol

C. Omnibus Budget Reconciliation Act

D. 1990 ANPRM notice

______________________ **12.** Ester based lubricants can be mixed with ___.

A. PFC refrigerants

B. mineral lubricating oils

C. glycol lubricating oils

D. no other lubricating oils

______ 13. The Montreal Protocol establishes requirements for phasing out ___ substances.

A. hydrofluorocarbon
B. hydrochlorofluorocarbon
C. perfluorocarbon
D. blended

______ 14. A gray body and a yellow top on a refrigerant cylinder indicates the cylinder is designed to hold ___.

A. new refrigerant
B. recovered refrigerant
C. dry nitrogen
D. trace gases

______ 15. CFC refrigerants are considered to be ___ dangerous to the environment.

A. the most
B. somewhat
C. not too
D. the least

______ 16. ___ is the recovery process where system components are used to remove refrigerant from a system.

A. The active method
B. The passive method
C. The self-contained method
D. Evacuation

______ 17. To determine the safe pressure for leak testing a system with nitrogen, a technician should use the ___.

A. high-side test-pressure nameplate value
B. low-side test-pressure nameplate value
C. compressor operating pressure
D. compressor discharge pressure

______ 18. Refrigerant labels are placed on cylinders to identify ___.

A. refrigerant to be returned for recycling
B. pressure
C. gross weight
D. the cylinder hauler

______ 19. ___ is typically used to leak check systems charged with R-134a refrigerant.

A. A halide torch
B. Trace gas
C. Dry nitrogen
D. Compressed air

______ 20. The refrigerant entering the expansion device of a refrigeration system is in a ___ state.

A. liquid
B. vapor
C. liquid-vapor
D. superheated vapor

_______________ **21.** One of the most serious results of ozone layer destruction is a(n) ___.

A. decrease in global warming
B. decrease in greenhouse gases
C. increase in skin cancer
D. increase in tree growth

_______________ **22.** Recovering refrigerant is required because ___.

A. refrigerants are toxic
B. adequate supplies are needed after production bans are in effect
C. money is saved by having reclamation facilities treat the refrigerant
D. venting the refrigerant is allowed after recovering the refrigerant first

_______________ **23.** Failure of a system to hold a vacuum at the end of the evacuation process indicates that ___.

A. a leak in the system exists
B. the system is ready to be charged
C. the compressor is overpressurizing the system
D. the metering device (expansion valve) is not operating

_______________ **24.** ___ results in a violation of the Clean Air Act.

A. Failing to recover liquid refrigerant first
B. Using long hoses on refrigerant recovery machines
C. Placing recovery cylinders in ice
D. Failing to reach required evacuation levels before opening or disposing of appliances

_______________ **25.** A technician servicing a refrigeration system with R-22 refrigerant discovers that R-502 refrigerant has been added to the system. The technician must ___.

A. recover the refrigerants for reuse
B. recycle the refrigerants for use in another system
C. vent as much of the R-502 refrigerant as possible, then recover the R-22 refrigerant
D. recover the refrigerants into a separate recovery container for waste disposal

TYPE I CERTIFICATION — Questions 26 through 50

_______________ **26.** Because small appliances have small amounts of refrigerant charge, the EPA states that small appliance leaks should be repaired ___.

A. within 30 days
B. when 35% of the charge escapes within a 12-month period
C. according to a submitted plan
D. whenever possible

_______________ **27.** Piercing-type access valves are used to enter systems through tubing made of ___.

A. iron
B. plastics
C. copper
D. steel

_______________ **28.** Because CFC and HCFC refrigerants typically have no odor, a strong, pungent odor during system servicing is a strong indication that ___.

A. excessive moisture is in the system
B. a compressor burnout has occurred
C. the system has a ternary blend of refrigerants
D. the refrigerant has been reclaimed

_______________ **29.** When system pressure of a small appliance is ___, the recovery process must not be started.

A. 0 psi

B. 14.7 in. Hg abs

C. 0 psia

D. 130 psi

_______________ **30.** The EPA requires capturing 80% of the refrigerant from a small appliance that has a nonoperating compressor if the recovery equipment was manufactured ___.

A. after November 15, 1993

B. before November 15, 1993

C. outside of North America

D. by a private citizen

_______________ **31.** ___ is a refrigerant blend of R-32, R-125, and R-134a refrigerants and is a popular ternary near-azeotropic mixture.

A. R-401a

B. R-407c

C. R-500

D. R- 502

_______________ **32.** Recovery equipment used to recover refrigerant from small appliances for the purpose of disposal must be able to recover 80% of the refrigerant from a system with a nonoperating compressor and ___% from a system with an operating compressor.

A. 60

B. 80

C. 90

D. 99

_______________ **33.** When ___, an excessive pressure condition on the high-pressure side of a self-contained (active) recovery device will exist.

A. the recovery container blue valve has not been opened

B. the system compressor is not operating

C. the blue Schrader valve on the system has not been opened

D. there is excessive air in the recovery container

_______________ **34.** ___ and ___ refrigerants create a binary refrigerant blend.

A. R-11; R-12

B. R-12; R-134a

C. R-12; R-22

D. R-22; R-115

_______________ **35.** When solderless-type piercing access valves are used, the valves must not remain installed on refrigeration systems after completion of repairs because solderless-type piercing valves ___.

A. would dramatically increase the cost of small appliance servicing

B. create an excess amount of resistance to system flow

C. tend to leak over time

D. fail closed, causing compressor damage

_______________ **36.** When used as a refrigerant for small appliances such as campers or recreational vehicles, ___ is recovered with specialty recovery devices.

A. R-22

B. R-205

C. ammonia

D. Halon

_______ **37.** Vapors from refrigerants such as R-12, R-22, and R-500 can cause suffocation because the refrigerants ___.

A. are toxic

B. mix with oxygen and create a toxic substance (chlorine monoxide)

C. are heavier than air and displace oxygen

D. are lighter than air and cause unconsciousness

_______ **38.** When a graduated charging device is being used to fill a cylinder, vented refrigerant from the cylinder ___.

A. need not be recovered

B. must be recovered

C. is considered a de minimis release

D. is not classified under Section 608

_______ **39.** Refrigerant recovery machines must be connected to recovery containers and small appliances by hoses and low-loss fittings that ___.

A. leak de minimis amounts of refrigerant when used for more than one disconnect

B. leak de minimis amounts of refrigerant during normal use

C. can be manually closed or closed automatically when disconnected to prevent loss of refrigerant from the hoses

D. cannot not be twisted

_______ **40.** As of November 14, 1994, the sale of CFC and HCFC refrigerants was ___.

A. banned, except for technicians that are Section 609 certified

B. limited to technicians purchasing less than 5 lb

C. restricted to technicians certified in refrigerant recovery

D. allowed only if the refrigerant was recycled

_______ **41.** After installing an access fitting onto a sealed small appliance system, ___.

A. the fitting must be leak tested before proceeding with recovery

B. it is not necessary to leak test an access fitting

C. the fitting need not be leak tested until the total repair is completed

D. the system must be pressurized with dry nitrogen before leak testing can be attempted

_______ **42.** During the system-dependent (passive) recovery process, both the high-pressure and low-pressure sides of the small appliance must be accessed for refrigerant recovery when the ___.

A. pilot line of the TXV valve is clogged

B. system has been overcharged

C. compressor does not run

D. condenser medium is at an excessively high temperature

_______ **43.** When a large leak of refrigerant occurs such as from a filled cylinder in an enclosed area, and no self-contained breathing apparatus is available, the technician must ___.

A. use butyl-lined gloves and a dust mask and try to stop the leak

B. vacate and ventilate the leak area

C. turn the cylinder upside down to force liquid refrigerant to the leak

D. use an M-2 mask

_______ **44.** On small appliances, the mandatory access service port (aperture) typically is ___.

A. a straight piece of tubing

B. a fitting located anywhere but 15″ below the compressor

C. installed at the factory in the suction line with ¼″ diameter machine threads

D. not present because small appliances are exempt from this requirement

_______________ **45.** When a reclamation facility receives a container of mixed refrigerants, the reclamation facility ___.

A. may refuse to reclaim the refrigerant mixture
B. will separate the refrigerant mixture
C. will process and store the refrigerant mixture for an additional cost
D. may resell the refrigerant mixture to a company with the same type of small appliance

_______________ **46.** When nitrogen is used to pressurize a small appliance, the nitrogen tank must be equipped with a ___.

A. fill sensor
B. regulator and relief valve
C. four-valve gauge manifold
D. filter regulator lubricator (FRL)

_______________ **47.** When performing a passive recovery process, a technician must ___ of the small appliance and recover refrigerant from the high-pressure side of the system.

A. access the refrigerant through the metering device
B. bypass the metering device
C. access the refrigerant from the top of the condenser
D. run the compressor

_______________ **48.** Technicians receiving a passing grade on the core and small appliance examinations are certified to charge refrigerant into ___.

A. heat pumps with 5 lb or less of refrigerant
B. freezers with 10 lb or less of refrigerant
C. low-pressure systems
D. high-pressure split systems

_______________ **49.** A small appliance, according to EPA regulations, ___.

A. is manufactured with 5 lb or less of refrigerant charge and is hermetically sealed at the factory
B. is manufactured with less than 15 lb of refrigerant and has an open compressor
C. is a system with a compressor under ½ hp
D. operates at pressures greater than 450 psi

_______________ **50.** Refrigerant containers being used to ship refrigerant must meet ___ standards.

A. Occupational Health and Safety Administration (OSHA)
B. Department of Transportation (DOT)
C. Environmental Protection Agency (EPA)
D. Air Conditioning and Refrigeration Institute (ARI)

TYPE II CERTIFICATION Questions 51 through 75

_______________ **51.** A technician typically removes ice from a sight glass by ___.

A. warming the sight glass with a cylinder heater
B. scraping with a scraper or screwdriver
C. using warm water
D. spraying with alcohol

_______________ **52.** Typically, the most common maintenance task that must be performed on refrigerant recycling machines is to ___.

A. change the oil and filter
B. change the electrical cord
C. replace the compressor seals
D. replace the gauges

______________ **53.** When using recovery and recycling equipment manufactured after November 15, 1993, technicians must evacuate a high-pressure appliance containing 350 lb of CFC-12 to ___ before disposing of the appliance.

A. 0 psi

B. 4″ Hg vacuum

C. 10″ Hg vacuum

D. 15″ Hg vacuum

______________ **54.** Appliances containing CFC refrigerants need only be evacuated to atmospheric pressure when ___.

A. the repair is major

B. the repair is followed by an evacuation of the appliance to the environment

C. leaks in the appliance make evacuation to the prescribed level unattainable

D. the appliance is being disposed of

______________ **55.** A technician servicing an 80-ton split system finds that the easiest way to determine which refrigerant to add to the system is to ___.

A. analyze a sample of the refrigerant

B. use pressure readings of the system while operating

C. look at the nameplate of the system

D. ask the owner of the system

______________ **56.** EPA regulations require that leaking commercial and industrial process refrigeration systems be repaired when the leak rate exceeds ___% of the charge per year.

A. 0

B. 15

C. 25

D. 35

______________ **57.** Replacement of a(n) ___ is a repair that would always be considered "minor" under EPA regulations.

A. evaporator coil

B. filter/dryer

C. metering device

D. compressor

______________ **58.** A suction service valve that is cracked off of the backseat will have ___.

A. the gauge port closed

B. the system port closed

C. the gauge port closed and the system port open

D. all ports open

______________ **59.** High-pressure systems that use R-134a refrigerant are leak checked with ___.

A. pressurized nitrogen

B. oxygen

C. compressed air

D. R-134a refrigerant sensors

______________ **60.** When using recovery and recycling equipment manufactured before November 15, 1993, technicians must evacuate an appliance containing 75 lb of CFC-500 to ___ before making a major repair.

A. 0 psig

B. 4″ Hg vacuum

C. 10″ Hg vacuum

D. 15″ Hg vacuum

_______________ **61.** When a condenser is below the receiver of a high-pressure system, refrigerant recovery must begin from the ___.

A. outlet of the condenser
B. discharge of the compressor
C. liquid line entering the evaporator
D. suction side of the compressor

_______________ **62.** All air conditioning and refrigeration systems should be protected by a ___.

A. gauge manifold
B. sight glass/moisture indicator
C. service (king) valve
D. receiver

_______________ **63.** Recovering refrigerant from a high-pressure system in a ___ state minimizes the loss of compressor oil.

A. solid
B. liquid/vapor
C. liquid
D. vapor

_______________ **64.** When first inspecting a system with a hermetically sealed compressor when the system is known to be leaking, a technician should look for ___.

A. ice/frost around the area that is leaking
B. traces of liquid refrigerant
C. traces of refrigerant oil
D. a plugged filter/dryer

_______________ **65.** The removal of refrigerant from a system can be accomplished more quickly by ___.

A. heating the recovery container with a heating pad
B. using long hoses between the recovery unit and recovery container
C. recovering as much of the refrigerant as possible in a vapor state
D. transferring the refrigerant to an empty, evacuated storage container

_______________ **66.** After the required refrigerant recovery vacuum for an appliance has been achieved, a technician must ___.

A. immediately disconnect the recycling or recovery equipment and open the system for service
B. pressurize the system with a mixture of nitrogen and refrigerant to perform a leak test
C. wait for the vacuum to dissipate
D. wait a few minutes to see if the system pressure rises, indicating that there is still refrigerant in a liquid state or in the oil

_______________ **67.** Deep vacuums are measured in ___.

A. microns
B. psi
C. psia
D. inches of mercury absolute

_______________ **68.** Before recovering refrigerant from a system with R-22 refrigerant, a technician using a recovery/recycling machine to recover R-502 refrigerant must ___.

A. do nothing, as long as the recovery machine storage container is not full
B. change oil in the recovery machine and use an empty recovery container
C. change the expansion valve, hoses, and oil on the recovery machine
D. recover as much of the R-502 from the recovery machine as possible, change the filter, and evacuate

__________ 69. The ___ is part of the low-pressure side of a high-pressure system.

A. condenser

B. receiver

C. liquid line

D. accumulator

__________ 70. System-dependent recovery equipment can only be used when the ___.

A. compressor of the appliance is not operational

B. ambient temperature is over 125°F

C. appliance contains under 15 lb of refrigerant

D. appliance is leaking

__________ 71. When a new system has been assembled (built up) and is ready for leak testing, the first procedure to accomplish is to ___.

A. pressurize the system with an inert gas

B. evacuate the system

C. pressurize the system with the refrigerant to be used

D. ensure that the compressor is operational

__________ 72. After a technician follows the proper procedures for isolating the compressor of a R-502 system to be replaced, and the recovery equipment (manufactured after November 15, 1993) recovers 40 lb of refrigerant, the technician must ___ and replace the compressor.

A. evacuate and hold the isolated section to 10″ Hg vacuum

B. evacuate and hold the isolated section to 15″ Hg vacuum

C. pressurize the isolated section to 0 psi

D. pressurize the isolated section to 0 psia

__________ 73. Technicians save time recovering refrigerant from a high-pressure system by removing as much of the refrigerant as possible in the ___ state.

A. liquid

B. vapor

C. liquid-vapor

D. inert

__________ 74. After liquid refrigerant has been recovered from a high-pressure appliance, refrigerant vapor ___.

A. remains in the system with the next charge

B. is condensed by the recovery machine and recovered

C. is moved by the system compressor to the system receiver

D. is isolated in the system condenser

__________ 75. Refrigerant cannot be recovered without isolating the compressors of a parallel compressor system because ___.

A. only one compressor is required to recover the refrigerant

B. of an open equalization connection

C. the compressors are before and after the system accumulator

D. of the volume of refrigerant (more than 15 lb)

TYPE III CERTIFICATION

Questions 76 through 100

________ **76.** It is not true of low-pressure recycling and recovery equipment manufactured after November 15, 1993, that the equipment must ___.

A. be tested by an EPA-approved third party

B. meet vacuum standards more stringent than those met by equipment manufactured before November 15, 1993

C. be equipped with low-loss fittings

D. be able to handle more than one refrigerant

________ **77.** After recovering the liquid refrigerant from a low-pressure chiller, a technician must ___.

A. recover the oil from the system

B. pressurize the system with hot water

C. recover the refrigerant vapor

D. solvent-flush the entire system

________ **78.** Technicians must be aware that when evacuating a system to prescribed levels, the use of ___ could cause trapped water to freeze.

A. a moisture dryer

B. a large vacuum pump

C. nitrogen

D. R-22

________ **79.** A technician recovering refrigerant from a chiller suspected of having leaking tubes must ___ as a precaution.

A. drain the water from the evaporator and condenser

B. increase the rpm of the compressor

C. verify that the purge unit is operating properly

D. remove a rupture disk

________ **80.** When recovering refrigerant vapor from a low-pressure system, the ___ water supply must be ON.

A. chiller condenser

B. chiller evaporator

C. recovery machine condenser

D. recovery machine evaporator

________ **81.** ASHRAE Standard 15-1994 requires that each machinery room shall activate an alarm and mechanical ventilation before refrigerant concentrations exceed the ___.

A. threshold limit value – time weighted average (TLV – TWA)

B. upper threshold limit (UTL)

C. coefficient of performance (COP)

D. emergency exposure limit (EEL)

________ **82.** When using recovery and recycling equipment manufactured after November 15, 1993, technicians must evacuate low-pressure appliances to a level of ___ before disposing of the appliance.

A. 0 psi

B. 15″ Hg vacuum

C. 25″ Hg vacuum

D. 29″ Hg vacuum

_______________ **83.** Replacing a(n) ___ is considered a "major" repair under EPA regulations.

A. filter/dryer

B. condenser fan motor

C. switch

D. evaporator coil

_______________ **84.** EPA regulations require that all commercial and industrial low-pressure appliances containing more than 50 lb of refrigerant be repaired when the leak rate exceeds ___% of the charge per year.

A. 15

B. 25

C. 35

D. 45

_______________ **85.** Low-pressure appliances can be pressurized to atmospheric pressure when ___.

A. the repair is major

B. the repair is followed by an evacuation of the appliance to the environment

C. leaks in the appliance make evacuation to the prescribed level unattainable

D. the appliance is being disposed of

_______________ **86.** A leak detector probe used to check for refrigerant leaks in a condenser water box should be placed through a(n) ___ once the water is removed.

A. rupture disc opening

B. open relief valve

C. test plug opening

D. open drain valve

_______________ **87.** Leak testing a low-pressure chiller with nitrogen in excess of 10 psi could cause the ___ to fail.

A. condenser tubes

B. purge unit shells

C. evaporator tubes

D. rupture disc

_______________ **88.** Under EPA regulations, ___ can be used to pressurize a low-pressure system for nonmajor repairs.

A. warming the refrigerant with hot water

B. oxygen

C. compressed air

D. nitrogen

_______________ **89.** When pressurizing an empty low-pressure system for leak testing, the maximum test pressure allowed is ___ psi.

A. 5

B. 10

C. 20

D. 29

_______________ **90.** To remove refrigerant oil from a low-pressure system, the compressor oil should be heated to ___°F, because less refrigerant contaminates the oil at the higher temperature.

A. 85

B. 130

C. 180

D. 212

_______________ **91.** Water must be circulated through a chiller during system evacuation in order to ___.

A. prevent the freezing of water

B. keep the refrigerant from vaporizing

C. separate refrigerant oil from the refrigerant

D. maintain a constant refrigerant pressure

_______________ **92.** R-123 falls under the ___ code group of ASHRAE Standard 34.

A. A1

B. A3

C. B1

D. B2

_______________ **93.** When evacuating the refrigerant from a low-pressure chiller, the high-pressure cutout of the recovery machine is set for ___ psi.

A. 2

B. 5

C. 10

D. 15

_______________ **94.** A purge unit removes ___ from the refrigerant in a low-pressure chiller.

A. excess heat

B. compressor oil

C. solids

D. water (moisture) and air (noncondensables)

_______________ **95.** Charging refrigerant liquid into a refrigeration system under a 29″ Hg vacuum can cause the ___.

A. refrigerant to absorb excess moisture

B. purge unit to operate

C. system water to freeze

D. lubricating oil to freeze

_______________ **96.** R-11 or R-123 system refrigerant recovery starts with ___.

A. refrigerant vapor removal

B. liquid refrigerant removal

C. pressurizing the system

D. oil separation

_______________ **97.** After reaching the required recovery vacuum on a low-pressure appliance, technicians must ___.

A. immediately break the vacuum with nitrogen and open the system for service

B. wait a few minutes to see if system pressure rises, indicating that there is still refrigerant in liquid form or in the oil

C. immediately pressurize the system with nitrogen and perform a leak check

D. wait a few minutes and repeat the process

_______________ **98.** According to ASHRAE guideline 3-1990, if the pressure in a system rises from 1 mm Hg to a level above ___ mm Hg during a standing vacuum test, the system should be checked for leaks.

A. 1.5

B. 2.0

C. 2.5

D. 3.0

_______________ **99.** Refrigerant R-11 at a pressure of 18.1″ Hg vacuum has a saturation temperature of ___ °F.

A. 28

B. 32

C. 36

D. 40

_______________ **100.** A typical low-pressure chiller rupture disc relieves pressure at ___.

A. 12.2 psia

B. 0 psi

C. 15 psi

D. 20 psi

Appendix

CONTAINER COLOR CODING

Refrigerant Number	Chemical Composition	Container Color	Refrigerant Number	Chemical Composition	Container Color
R-11	CFC	Orange	R-401C	Zeotropic-HCFC	Blue-green
R-12	CFC	White	R-402A	Zeotropic-HCFC	Pale brown
R-13	CFC	Medium blue	R-402B	Zeotropic-HCFC	Green-brown
R-13B	CFC	Coral	R-404A	Zeotropic-HCFC	Orange
R-22	HCFC	Light green	R-406A	Zeotropic-HCFC	Light green-gray
R-23	HFC	Light gray	R-407A	Zeotropic-HCFC	Bright green
R-113	CFC	Purple	R-407B	Zeotropic-HFC	Peach
R-114	CFC	Dark blue	R-407C	Zeotropic-HFC	Chocolate brown
R-123	HCFC	Medium gray	R-410A	Zeotropic-HFC	Rose
R-124	HCFC	Deep green	R-500	Azeotropic-CFC	Yellow
R-125	HFC	Medium brown	R-502	Azeotropic-CFC	Light purple
R-134a	HFC	Light (sky) blue	R-503	Azeotropic-CFC	Aquamarine
R-401A	Zeotropic-HCFC	Coral red	R-507A	Azeotropic-HFC	Teal
R-401B	Zeotropic-HCFC	Mustard yellow			

PRESSURE-TEMPERATURE CHART

Temp*	R-11†	R-12†	R-22†	R-113†	R-114†	R-500†	R-502†	R-134a†	R-123†
–50	28.9‡	15.4‡	6.2‡		27.1‡		0.0	18.7‡	
–45	28.7‡	13.3‡	2.7‡		26.6‡		1.9	16.9‡	
–40	28.4‡	11.0‡	0.5		26.0‡	7.6‡	4.1	14.8‡	
–35	28.1‡	8.4‡	2.6		25.4‡	4.6‡	6.5	12.5‡	
–30	27.8‡	5.5‡	4.9	29.3‡	24.6‡	1.2‡	9.2	9.5‡	
–25	27.4‡	2.3‡	7.4	29.2‡	23.8‡	1.2	12.1	6.9‡	
–20	27.0‡	0.6	10.1	29.1‡	22.9‡	3.2	15.3	3.7‡	27.8‡
–15	26.5‡	2.4	13.2	26.9‡	21.9‡	5.4	18.8	0.6	27.4‡
–10	26.0‡	4.5	16.5	28.7‡	20.5‡	7.8	22.6	1.9	26.9‡
–5	25.4‡	6.7	20.1	28.5‡	19.3‡	10.4	26.7	4.0	26.4‡
0	24.7‡	9.2	24.0	28.2‡	17.8‡	13.3	31.1	6.5	25.9‡
5	23.9‡	11.8	28.2	27.9‡	16.2‡	16.4	35.9	9.1	25.2‡
10	23.1‡	14.5	32.8	27.6‡	14.4‡	19.7	41.0	11.9	24.5‡
15	22.1‡	17.7	37.7	27.2‡	12.4‡	23.4	46.5	15.0	23.8‡
20	21.1‡	21.0	43.0	26.8‡	10.2‡	27.3	52.4	18.4	22.8‡
25	19.9‡	24.5	48.8	26.3‡	7.8‡	31.5	58.8	22.1	21.8‡
30	18.6‡	28.5	54.9	25.8‡	5.2‡	36.0	65.6	26.1	20.7‡
35	17.2‡	32.6	31.5	25.2‡	2.3‡	40.9	72.8	30.4	19.5‡
40	15.5‡	37.0	68.5	25.5‡	0.4	46.1	80.5	34.1	18.1‡
50	13.9‡	41.7	76.0	25.8‡	2.0	51.4	88.7	40.1	16.6‡
50	12.0‡	46.7	84.0	22.9‡	3.8	57.6	97.4	45.5	14.9‡
55	10.0‡	52.0	92.6	22.2‡	5.8	63.9	106.6	51.3	13.0‡
60	7.8‡	57.7	101.6	21.0‡	7.9	70.6	116.4	57.5	11.2‡
65	5.4‡	63.8	111.2	19.9‡	10.1	77.8	126.7	54.1	8.9‡
70	2.8	70.2	121.4	18.7‡	12.6	85.4	137.6	71.2	6.5‡
75	0.0	77.0	132.2	17.3‡	15.2	93.3	149.1	78.8	4.1‡
80	1.5	84.2	143.6	15.9‡	18.0	102.0	161.2	86.8	1.2‡
85	3.2	91.8	155.7	14.3‡	20.9	111.0	174.0	95.4	0.9
90	4.9	99.8	168.4	12.5‡	24.1	120.6	187.2	104.4	2.5
95	6.8	108.3	181.8	10.6‡	27.56	130.6	201.4	114.1	4.3
100	8.8	117.2	195.9	8.6‡	31.2	141.2	216.2	124.3	6.1
105	10.9	126.6	210.8	6.4‡	35.0	162.4	231.7	135.1	8.1
110	13.2	136.4	226.4	4.0‡	39.1	165.1	247.9	146.5	10.3
115	15.6	146.8	242.7	1.4‡	43.4	176.5	264.9	158.6	12.6
120	18.2	157.7	259.9	0.7	48.0	189.4	282.7	171.3	15.1
125	21.0	169.1	277.9	2.2	52.8	203.0	301.4	184.7	17.8
130	24.0	181.0	296.8	3.7	58.0	217.2	320.8	196.9	20.6
135	27.1	192.5	316.6	5.4	63.4	232.1	341.2	213.7	23.6
140	30.4	206.6	337.3	7.2	68.1	247.7	362.6	229.4	26.8
145	34.0	220.3	358.9	9.2	75.1			245.8	30.2
150	37.7	234.5	381.5	11.2	81.4			263.0	33.9

* in °F
† in psi
‡ in inches of mercury

Refrigerant Usage Log

Job Number: ______________________

Unit Name: ______________________ Unit Location: ______________________

Equipment Description: ______________________

Refrigerant Type: ______________________ Oil Type: ______________________

Filter Changed (Y/N): ______________________ Amount of Oil Removed: ______________________

Amount Recovered: ______________________ Recovery Unit: ______________________

Why Recovered: ______________________ Serial Number: ______________________

Recovered Sent to: ______________________

Amount Recycled: ______________________ Recycling Unit: ______________________

Why Recycled: ______________________ Serial Number: ______________________

Recycled sent to: ______________________

Amount Charged: ______________________ Charging Unit: ______________________

Reason for Charge: ______________________ Serial Number: ______________________

Acid Test: ______________________

Moisture Test: ______________________

Date: ______________________ Technician Signature: ______________________

Comments: ______________________

New Refrigerant Use Log

Employee Name ______________________________ Employee No. __________ Truck No. __________

Week End Date ______________________________ Page ______ of ______

Date	Customer Name	Job No.	Refrigerant R-12	Refrigerant R-22	Refrigerant R-500	Refrigerant R-502

	Refrigerant Types					
	R-12	R-22			Received by	Date
Empty disposable tanks turned in						
Reclaim refrigerant returned Quantity by pound						
New refrigerant given Quantity						
Date						
Quantity						
Date						

Contaminated/mixed refrigerant returned in red-tagged drum

Lb of Refrigerant		Drum Serial No.	
Received by		Date	

Refrigerant Recovery Report

Customer Name ______________________________ Date __________

Address ______________________ City ______________ Job No. __________

Equipment Manufacturer	Model Number	Serial Number	Refrigerant Type

Reason for Incident ______________________________

Integrity of Refrigerant Acid ☐ Yes ☐ No Moisture ☐ Yes ☐ No

Refrigerant Recovery Model No. ☐ Company Serial No. ☐

Hour Meter Reading: Start ________ Finish ________ Company Serial No. of Recovery Drum ________

Weight of Recovery Drum: Start ________ Finish ________ Total lb Refrigerant Recovered ________

Refrigerant Filtered and Dried during Removal? ☐ Yes ☐ No Compressor Meg Reading before Removal ________

Disposition of Refrigerant: ☐ Recycle ☐ Reclaim ☐ Disposal

Comments: ______________________________

Leak Repair Report

Method Used for Leak Detection ______________________________

____

Materials Used for Leak Detection ______________________________

____

All Refrigerant Removed Prior to Putting in Nitrogen? ☐ Yes ☐ No

Nitrogen Vented to Atmosphere? ☐ Yes ☐ No Customer Advised? ☐ Yes ☐ No

Reason Leak Happened? ______________________________

____

Method Used to Repair Leak and Improvements Made to Keep This from Happening Again ________

____

Technician Name ______________________ Employee Number ________

Customer Signature ______________________ Date ________

Appliance Inventory Report

Installation Date: ____________________ Disposal Date: ____________________

Appliance Name/Designation: ____________________ Facility Manager: ____________________

Appliance Location: ____________________ Phone Number: ____________________

Manufacturer: ____________________ Model: ____________________

Serial Number: ____________________ Capacity (Btu/Ton): ____________________

Refrigerant Type: ____________________ Refrigerant Quantity (lb/oz): ____________________

Volt/Phase/Hz: ____________________ Lubricant: ____________________

Duty Type (Comfort, Process, Under 50 lb, Other): ____________________

Approximate Quantity of Refrigerant Added (per Year): ____________________

Approximate Repair Costs (per Year): ____________________

Containment Upgrades Added: ____________________

____

____

Estimated Costs ____________________

Contain: ____________________

Engineering Retrofit: ____________________

Replace: ____________________

Recommendation

Contain: ____________________

Engineering Retrofit: ____________________

Contain: ____________________

Engineering Retrofit: ____________________

Replace: ____________________

Comments: ____________________

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Accidental Refrigerant Release Report

Job Number/Charge Number: ____________________ Report Number: ____________________

Technician Name: ____________________ Service Date: ____________________

Event Location (Address, Building, Area/Unit Location): ____________________

Leak Location: ____________________

Refrigerant Type: ____________________ Equipment Name/Number: ____________________

Approximate lb of Refrigerant Vented: ____________________

Description of Event: ____________________

Why did the event occur? ____________________

What future precautions will be used to prevent this kind of event? ____________________

Who was aware of the situation (Name, Employee Number)? ____________________

Who has been informed of the situation (Name, Employee Number)? ____________________

Signed: ____________________ Date: ____________________

Appendix Disposal Report

Disposal Date: ____________________

Appliance Name/Designation: ____________________

Technician Name: ____________________

Appliance Location: ____________________

____

Certification Number: ____________________

Manufacturer: ____________________

Model: ____________________

Serial Number: ____________________

Capacity (Btu/Ton): ____________________

Refrigerant Type: ____________________

Volt/Phase/Hz: ____________________

Lubricant: ____________________

Duty Type (Comfort, Process, Under 50 lb, Other): ____________________

Disposal Destination: ____________________

____

____

Recovery/Recycle Equipment Used: ____________________

System Pressure during Evacuation (inches of Hg vacuum): ____________________

Refrigerant Extracted (lb/oz): ____________________

Cylinder Used: ____________________

Comments: ____________________

____

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I hereby certify that the recovery equipment was used properly and that the refrigerant was evacuated to EPA's specified levels.

Signed: ____________________ Date: ____________________

Recovery/Reclaimed Refrigerant Shipping Log

Ship Date	Refrigerant		Refrigerant		Carrier	Bill of Lading #	Container #	Initials	Return Date
	Type	Cylinder ID	lb	oz					

Total Refrigerant: ________ ________

Refrigerant Purchase Log

For Month of: ____________________

Order Date	Refrigerant		Refrigerant		Supplier	Amount of Purchase	Purchase Order #	Initials	Receive Date
	Type	Cylinder ID	lb	oz					

Total Refrigerant: ________ ________

Request for Laboratory Analysis

Company: ____________________ Purchase Order Number: ____________________

Address: ____________________ Sample Cylinder Number: ____________________

City: ____________________ Customer Reference: ____________________

State: __________ Zip: __________ Contact: ____________________

Phone: ____________________ Fax:

Analysis Requested:

Refrigerant Type: ____________________

Complete Analysis: __________ Purity (99.6%) __________ Moisture (10 ppm max) __________

Chloride (Pass/Fail) __________ Residue (.01 max) __________ Particulates/Solids (Pass/Fail) __________

Acidity (3 ppm max) __________ Noncondensable gases __________ (test must be performed on a vapor sample)

Refrigerant Type: ____________________

Complete Analysis: __________ Purity (99.6%) __________ Moisture (10 ppm max) __________

Chloride (Pass/Fail) __________ Residue (.01 max) __________ Particulates/Solids (Pass/Fail) __________

Acidity (3 ppm max) __________ Noncondensable gases __________ (test must be performed on a vapor sample)

Halon Type: ____________________

Complete Analysis: Purity (99.6%) __________ Moisture (10 ppm max) __________

Halon™ Ion (Pass/Fail) Residue (.01 max) __________ Suspended Matter (Pass/Fail) __________

Acidity (3 ppm max) __________ Noncondensable gases __________ (test must be performed on a vapor sample)

Comment: ____________________

____

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____

Signature: ____________________ Date: ____________________

Ship sample and request form to: ____________________

____

A

absolute pressure: Any pressure above a perfect vacuum (0 psia).

active recovery: A refrigerant recovery process using a self-contained recovery unit (machine).

Air Conditioning and Refrigeration Institute (ARI): A national trade association representing 90% of all North American manufacturers producing air conditioning and refrigeration equipment.

alkylbenzene: A synthetic lubricant made from propylene and benzene that is used with HCFC-based refrigerants and refrigerant blends.

American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE): An organization that advances the arts and sciences of heating, ventilation, air conditioning, and refrigeration systems.

atmospheric pressure: The force exerted by the weight of the atmosphere on the surface of the Earth.

azeotrópic mixture: A refrigerant blend that behaves like a new refrigerant made from one chemical.

B

backseat a valve: To turn the valve in the counterclockwise direction to bring the valve stem to the front position.

blend: A mixture of two or more different chemical compounds.

boiling point: The temperature at which a liquid vaporizes.

C

caution: A signal word that is used to indicate a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

chemical gloves: Gloves made of rubber (butyl), Silver Shield™, or neoprene and used to provide protection when handling refrigerants.

chiller: A piece of refrigeration equipment that removes heat from water that circulates through a building for cooling purposes.

chlorofluorocarbon (CFC) refrigerant: A refrigerant that consists of chlorine, fluorine, and carbon.

class I substance: A refrigerant that poses the highest danger to the environment.

class II substance: A refrigerant that is considered to present a medium danger to the environment.

code: A regulation or minimum requirement.

compressor: A mechanical device that compresses refrigerant or other fluid.

compressor discharge pressure: The pressure created by the resistance to flow of the refrigerant when discharged from the compressor.

compressor suction pressure: The lower pressure created at the suction port of a compressor as refrigerant is drawn into the compressor.

condenser: A heat exchanger that removes heat from highpressure refrigerant vapor.

condensing medium: A fluid (air or water) that has a lower temperature than the refrigerant, which causes heat to flow to the medium.

condensing point: The temperature at which a vapor condenses to a liquid.

cylinder unloader: A device that holds the suction valve closed or holds the suction valve open on a cylinder.

D

danger: A signal word that is used to indicate an imminently hazardous situation which, if not avoided, will result in death or serious injury.

decibel (dB): A unit of measure used to express the relative intensity of sound.

dehydration: The process of removing moisture (water vapor) from air conditioning or refrigeration systems.

disposable container (cylinder): A container used only with new refrigerants.

DOT reusable container: An empty container that is shipped to a facility where the container will be filled, labeled with a DOT classification tag, and shipped again.

E

earmuff: An ear protection device worn over the ears.

earplug: An ear protection device made of moldable rubber, foam, or plastic that is inserted into the ear canal.

electronic leak detector: A leak detector that detects the presence of halogen gas.

Environmental Protection Agency (EPA): A government agency that protects human health and the environment.

evacuation: The process of removing air and moisture from air conditioning or refrigeration systems.

evaporating medium: A fluid (air or water) that is cooled when heat is transferred from the medium to the cold refrigerant.

evaporator: A heat exchanger where heat is absorbed into the lowpressure liquid refrigerant.

expansion valve: A valve or mechanical device that reduces the pressure of liquid refrigerant by allowing the refrigerant to expand.

explosion warning: A signal word that is used to indicate locations and conditions where exploding parts may cause death or serious personal injury if proper precautions and procedures are not followed.

eye protection: Devices that must be worn to prevent eye or face injuries caused by flying particles or refrigerant spray.

F

face shield: An eye and face protection device that covers the entire face with a plastic shield and is used for protection from flying objects or splashing refrigerants.

fire point: The temperature (higher than flash point) at which a fluid will burn for at least 5 seconds.

fixed leak detector: A stationary leak detector system with sensors and controllers to detect one specific type of refrigerant.

flash point: The temperature at which a fluid's vapor will ignite without the fluid igniting.

fluorescent leak detector: A leak detector that uses a UV light to detect fluorescent dye that was added to a system.

fractionation: When liquid and vapor are coexisting simultaneously, with one or more refrigerants of a blend leaking at faster rates than other refrigerants of the same blend.

G

gauge manifold: A device that has two gauges, a manifold with valves, and connecting hoses to control refrigerant transfer.

gauge pressure: Pressure above atmospheric pressure that is used to express pressures inside a closed system.

global warming potential (GWP): A number given to refrigerants to represent the relative global warming potential of a refrigerant (refrigerants are considered greenhouse gases).

glycol: A refrigerant lubricant used with HFC-based refrigerants.

goggles: An eye protection device with a flexible frame that is secured on the face with an elastic headband.

H

halide torch leak detector: A leak detector that uses a torch flame that changes color depending on which refrigerant is exposed to the copper element.

hot gas discharge line: The pipe or tubing that connects the compressor to the condenser.

hydrochlorofluorocarbon (HCFC) refrigerant: A refrigerant that consists of hydrogen, chlorine, fluorine, and carbon.

hydrofluorocarbon (HFC) refrigerant: A refrigerant that consists of hydrogen, fluorine, and carbon.

hydrostatic tube test kit: A set of tools used to determine if tubes are leaking in the condenser of a chiller.

L

leak detector: A device that is used to detect refrigerant leaks in a pressurized air conditioning or refrigeration system.

liquid line: The refrigerant pipe or tubing that connects the condenser outlet and the expansion device.

lockout: The process of removing the source of electrical power and installing a lock that prevents the power from being turned ON.

low-loss fittings: Special fittings that prevent the release of refrigerant from a system to the atmosphere and prevent air from entering the system.

M

mechanical compression refrigeration: A refrigeration process that produces a refrigeration effect with mechanical equipment.

mercury barometer: An instrument used to measure atmospheric pressure and calibrated in inches of mercury absolute (in. Hg abs).

metering device: A valve or orifice in a refrigeration system that controls the flow of refrigerant into the evaporator to maintain the correct evaporating medium temperature.

O

orifice-type metering device: A small, fixed opening that is used as a restriction in the liquid line between the condenser and the evaporator of a refrigeration system.

ozone depletion potential (ODP): A number given to refrigerants to represent the relative ozone depletion potential of a refrigerant.

P

passive recovery: A refrigerant recovery process achieved with the assistance of system components to remove the refrigerant from the system (pump-down).

perfluorocarbon (PFC) refrigerant: A refrigerant that consists of carbon and fluorine and that does not deplete stratospheric ozone but has an extremely high global warming potential.

personal protective equipment (PPE): Gear worn by technicians to reduce the possibility of injury when charging, recovering, or recycling refrigerants.

pour point: The lowest temperature a fluid can be at and still flow.

pressure: The force per unit of area that is exerted by an object or a fluid.

pressure-temperature (P-T) chart: A reference tool used to determine the pressure of a refrigerant at a given temperature or to determine the temperature of a refrigerant at a given pressure.

protective clothing: Clothing made of durable material such as denim and provides protection from contact with sharp objects, cold equipment, and harmful materials.

protective helmet: A hat that is used in work areas to prevent injury from the impact of falling and flying objects.

purge unit: A device that removes noncondensables (air and moisture) from the centrifugal system during normal operation and returns the recycled refrigerant to the system.

R

refrigerant: A fluid (liquid or vapor) in a refrigeration system that accomplishes heat transfer by absorbing heat (evaporator) to change state from a liquid to a vapor or giving up heat (condenser) to change state from a vapor to a liquid.

refrigerant document: A form used for proving innocence in the face of an accusation of misconduct.

refrigerant oil: Oil used to lubricate the compressor bearings of a refrigeration system.

refrigerant reclaiming: The reprocessing of used refrigerant to meet new refrigerant standards, which includes chemical analysis to verify purity.

refrigerant recovery: The removal of refrigerant in any condition from a system without testing or processing the refrigerant and storing the refrigerant in an external container.

refrigerant recycling: The removal of refrigerant from a system and the cleaning of the refrigerant for reuse.

refrigerant retrofit: The changing of refrigerants by following the instructions of the manufacturer for refrigerant replacement.

refrigerant transition and recovery certification card: An ID card that documents that the holder is qualified to safely recover, recycle, charge, and purchase or sell refrigerants.

refrigeration: The process of moving heat from an area where it is undesirable to an area where the heat is not objectionable.

refrigeration system: A closed system that controls the pressure and temperature of a refrigerant to regulate the absorption and rejection of heat by the refrigerant.

respirator: A device worn by technicians to protect against the inhalation of potentially hazardous refrigerant vapors.

reusable container (cylinder): A gray container with a yellow top designed to receive refrigerant and have refrigerant extracted.

rupture disc: A nonmechanical pressure-relieving device that bursts open to relieve an overpressure condition at a predetermined pressure differential and specific temperature.

S

safety data sheet (SDS): A printed document used to relay hazardous material information from the manufacturer, importer, or distributor to the technician.

safety glasses: An eye protection device with special impact-resistant glass or plastic lenses, reinforced frames, and possibly side shields.

safety label: A sticker that indicates areas or tasks that can pose a hazard to personnel and/or air conditioning and refrigeration equipment.

service aperture: A device used to add or remove refrigerant from a system.

standard: An accepted reference or practice.

subcooling: The cooling of a refrigerant to a temperature that is lower than the saturated temperature of the refrigerant for a particular pressure.

suction line: The pipe or tubing that connects the evaporator and the suction port of the compressor.

superheat: The heat added to a refrigerant after the refrigerant has changed state into a vapor.

T

tagout: The process of placing a danger tag on the source of electrical power, which indicates that the equipment may not be operated until the lock and/or danger tag is removed.

temperature glide: A range of temperatures where refrigerants condense or evaporate for one given pressure.

thermostatic expansion valve (TXV): A valve that uses the temperature of the refrigerant discharged from an evaporator to control the liquid refrigerant flowing into an evaporator.

U

ultrasonic leak detector: A leak detector that senses the sounds created by a leak.

ultraviolet radiation: The portion of the light spectrum that is damaging to living organisms.

V

vacuum: Any pressure lower than atmospheric pressure.

vacuum pump: A device used to create pressures below atmospheric pressure (vacuum in in. Hg) in a closed system.

viscosity: The measurement of a fluid's internal resistance to flow.

W

warning: A signal word that is used to indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury.

work order: A form used for accounting purposes.

Z

zeotropic mixture: A refrigerant blend in which individual refrigerants of the mixture behave independently.

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Technician Certification for Refrigerants provides information on the recovery of refrigerants from air conditioning and refrigeration equipment. This third edition is specifically designed and organized for easy use in preparation for Type I, Type II, Type III, and Universal 608 refrigerant certification card tests and the Canadian ozone depletion potential (ODP) certification card test. Vignettes on technical topics, Environmental Protection Agency (EPA) standards, and common refrigerant recovery and charging procedures are located throughout the book to enhance understanding of the content covered.

Key features of this new edition include the following:

- Canadian ODP certification standards
- Sample Canadian certification card test
- Updated refrigerant information
- Step-by-step procedures of refrigerant recovery and system evacuation operations

This book includes information on the latest generation of refrigerants and the most current EPA and Environment Canada standards and regulations. Chapters 1–7, 9, 11, 13, 15, and 17 offer a comprehensive learning experience. Chapters 8, 10, 12, 14, and 16 contain hundreds of updated sample Type I, Type II, Type III, 608, and Canadian certification test questions. Chapter 18 is a sample Universal certification test that has also been updated for the third edition.

The Digital Resources included with the textbook feature the following:

- **Quick Quizzes®** that provide 10 interactive questions for each chapter to reinforce fundamental concepts
- An **Illustrated Glossary** of terms, with links to selected illustrations
- **Flash Cards** for the review of common refrigerant and HVAC terms, definitions, and refrigeration system test tools
- **Sample Certification Tests** organized into five 25-question tests that provide practice with refrigeration certification tests in the United States and refrigerant-handling certification tests in Canada
- **Interactive Animations** that present refrigerant recovery procedures for Type I and Type II refrigeration systems per Section 608 of the Clean Air Act
- **Step-by-Step Procedures** that cover common refrigerant-handling tasks with drawings and concise text
- **Compliance Forms** that provide documentation for purchasing and working with refrigerants
- A **Media Library** that depicts principles and tasks using media clips and animations
- **ATPeResources.com,** which provides a comprehensive array of instructional resources

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